...TMENT OF TECHNOLOGY
...ERIE COUNTY PUBLIC LIBRARY

Aeronautical Engineering REVIEW

February, 1956

AMERICAN AIRLINES chooses

America's Leading Airline

Aeroproducts Propellers

for its new fleet of Allison-powered Lockheed Electras

The Lockheed Electra airliners, setting the pace for the era of jet-powered transports and now in production for American Airlines, will be equipped with the proved team of Aeroproducts Propellers and Allison turbine engines. Both are products of General Motors.

Just as the Allison Turbo-Prop engines were selected because they are the most advanced in the world today, American chose Aeroproducts Propellers after the most careful evaluation. The decision in favor of Aeroproducts was based on rugged blade construction combined with unique features of pitch control and dependability. Result of more than ten years' intensive development, the Aeroproducts turbine propeller made its first flight in December 1945, in the first Turbo-Prop airplane to fly in the United States.

Since then, this General Motors power package of Allison engines and Aeroproducts Propellers has accumulated thousands of hours of successful flight experience in the Allison Turbo-Liner, the Air Force C-131C Transport and the Navy R3Y "Tradewind."

Now the advantages of Turbo-Prop power, demonstrated in this military experience, will be applied to commercial travel by air. The new four-engine Electras will cruise comfortably at more than 400 miles an hour —bringing speed and smoothness to short and medium-range flights. With the ability to take off and land on existing runways, these new Turbo-Prop transports will operate into any airport now regularly served.

Building for today...Designing for tomorrow

Aeroproducts

ALLISON DIVISION OF GENERAL MOTORS • DAYTON, OHIO

tmorrow

ets

N. OHIO

I.A.S. News Notes

February 1956

CLIFFORD C. FURNAS, FIAS, Assistant Secretary of Defense for Research and Development, will be the dinner speaker March 9 at the Eleventh Annual Flight Propulsion Meeting of the IAS in Cleveland. The reception and dinner in Hotel Carter will be sponsored by the Cleveland-Akron Section. Eight technical papers, all confidential, will be delivered during the day. Attendance at the technical session will be limited to those who have obtained security clearance in advance.

JOINT SESSIONS on Air Cargo and Air Logistics are scheduled for March 14-16 at Hotel Statler, Los Angeles, sponsored by the IAS and the Aviation Division of the ASME. E. W. Robischon, Western Region Manager of the IAS, will be Vice Chairman of one session. The 3-day meeting, which will also include a joint session with the American Rocket Society on thermal barrier problems, will close with a field trip to inspect the C-133 transport at the Long Beach plant of Douglas Aircraft Company, Inc.

THE NATIONAL TURBINE-POWERED AIR TRANSPORTATION MEETING, which for the past two years has been held in Seattle, will take place in San Diego this summer. It has been scheduled for August 15-17 with headquarters at the Grant Hotel. Earl R. Hinz is General Chairman of the Committee and Charles Blake, Co-Chairman.

RALPH S. DAMON, 58, President of Trans World Airlines, Inc., died on January 4. He had just been elected the American Honorary Fellow of the Institute for 1955.

TWO NEW STUDENT BRANCHES of the IAS have been organized: one at Stevens Institute of Technology, Hoboken, N. J., and the other at University of Kentucky, Lexington, Ky.

NATIONAL MEETINGS CALENDAR

Mar. 9 Flight Propulsion Meeting (Confidential), Hotel Carter, Cleveland.
June 18-21 Summer Meeting, IAS Building, Los Angeles.
Aug. 15-17 Turbine-Powered Air Transportation Meeting, Grant Hotel, San Diego, California.

JOINT MEETINGS CALENDAR

Mar. 14-16 ASME-IAS-ARS Air Cargo and Thermal Barrier Sessions, Hotel Statler, Los Angeles.
May 14-16 National Conference on Aeronautical Electronics, Biltmore Hotel, Dayton, Ohio. Co-sponsored with IRE.
June 21-23 Heat Transfer and Fluid Mechanics Institute, Stanford University, Stanford, California.
Aug. 20-21 National Telemetering Conference, Biltmore Hotel, Los Angeles, Co-sponsored with AIEE, IRE, and ISA.

* * *

I.A.S. News Notes (con't.)

SECTION MEETINGS CALENDAR

Feb. 3 Texas Section: Room 205, Fort Worth International Airport. Reception 7 p.m., Dinner 8 p.m., Meeting 9:15 p.m. "The Missile Grows Up" by S. O. Perry, Asst. Chief Engineer, Chance Vought.

Feb. 7 Los Angeles Section: Specialist Meeting at IAS Building, 8 p.m. "Stability of Orthotropic Cylindrical Shells Subjected to Axial Compression or External Radical Pressure" by N. J. Ryker.

Feb. 7 San Diego Section: Confidential Technical Meeting, IAS Building, 8 p.m. "Development of High-Performance Fighters" by Ralph Bayless, Chief Engineer, Convair-San Diego.

Feb. 8 Texas Section: Joint Meeting with Texas Soaring Assn., Arlington State College, 8 p.m. "Flow Visualization as a Tool in Aerodynamics" and "Remarks on the Aerodyne" by Alexander M. Lippisch, Dir., Aeronautical Research Laboratory, Collins Radio Company.

Feb. 13 Indianapolis Section: B&B Restaurant. Reception 6:30 p.m., Dinner 7 p.m., Meeting 8 p.m. "Reverse Thrust" by Paul P. Datner, Senior Engineer, Aerojet-General Corporation.

Feb. 14 Washington Section: Occidental Restaurant. Reception 6 p.m., Dinner 6:45 p.m., Meeting 8 p.m. "Decision Making in a Complex Organization" and "The Measurement of Leadtimes" by Charles M. Mottley, Office of Asst. Secretary Defense (R&D), and Richard B. Foster, Stanford Research Institute.

Feb. 15 Boston Section: Sylvania Electric Products, Inc., Waltham, 8 p.m. "The Air Traffic Control Problem" by Ben F. Greene, Chief, Navigation Laboratory, USAF Cambridge Research Center, Cambridge.

Feb. 16 Cleveland-Akron Section: Joint Meeting with ARS, Hotel Hollenden, Cleveland. Reception 6 p.m., Dinner 7 p.m., Meeting 8 p.m. "Applications and Design of Earth Satellites" by S. Fred Singer, Associate Professor of Physics, University of Maryland.

Feb. 16 Dayton Section: Cordell's Supper Club, Fairborn. "Nuclear Propulsion in Transportation" by N. J. Bifano and J. Moteff.

Feb. 16 Los Angeles Section: IAS Building. Reception 6 p.m., Dinner 7 p.m., Meeting 8 p.m. "The Area Rule" by Richard T. Whitcomb of Langley Lab., NACA, with comment by K. E. Van Every, D. H. Bennett and Jim Hong.

Feb. 16 New York Section: Garden City Hotel, Garden City, L.I. Reception 6 p.m., Dinner 7 p.m., Meeting 8 p.m. Talk by A. W. Hetherington, Human Factors Division, ARDC, USAF.

Feb. 21 Los Angeles Section: Specialist Meeting at IAS Building, 8 p.m. "Applications of Statistical Analysis to Ram-Jet Control Systems Design" by E. E. Kinsey.

Feb. 22 St. Louis Section: Congress Hotel, 8 p.m. "The Professional Status of the Aeronautical Engineer" by R. C. Sonnemann, Personnel Manager, McDonnell Aircraft Corporation.

Feb. 24 Texas Section: "DC-3 Replacement Transport" by Jack Frye, 8 p.m. Place to be announced.

Feb. 28 Los Angeles Section: Field Trip to McCulloch Motors, Los Angeles. Dinner 6 p.m., Plant Tour 7 p.m.

T
auth
ture
chus
as I
ing.
T
Rese
Cha
Prof
of 3
U.S.
rium
Pr
lectu
Dub
Rese

IAS News

A Record of People and Events of Interest to Institute Members

The Nineteenth Wright Brothers Lecture

R. L. Bisplinghoff of M.I.T. Discusses Structures and Aeroelasticity in High-Speed Aircraft

THE WRIGHT BROTHERS LECTURE on December 17 bore the timely title: "Some Structural and Aeroelastic Considerations of High-Speed Flight." Its author, Raymond L. Bisplinghoff, AFIAS, is Director of the Aeroelastic and Structures Research Laboratory at Massachusetts Institute of Technology, as well as Professor of Aeronautical Engineering.

T. P. Wright, Vice-President for Research, Cornell University, was Chairman of the meeting and introduced Professor Bisplinghoff to the audience of 300 IAS members and guests in the U.S. Chamber of Commerce Auditorium, Washington, D.C.

Prepared discussions following the lecture were presented by John E. Duberg, MIAS, Chief of the Structures Research Division, Langley Aeronautical Laboratory, National Advisory Committee for Aeronautics; Nicholas J. Hoff, FIAS, Head of the Department of Aeronautical Engineering and Applied Mechanics, Polytechnic Institute of Brooklyn; and Alexander Kartveli, FIAS, Vice-President and Chief Engineer of Republic Aviation Corp.

In his introductory remarks, Professor Bisplinghoff pointed out that never before in the history of the airplane have matters of structural strength, rigidity, life, and weight been the subject of greater concern.

Left to right, seated: T. P. Wright, R. L. Bisplinghoff, and Nicholas J. Hoff. *Standing:* John E. Duberg, Alexander Kartveli, and S. Paul Johnston.

Raymond L. Bisplinghoff

"Since the close of World War II," he said, "technical advances in power plants and aerodynamics have been phenomenal. The rapid development of the gas turbine has produced the greatest aeronautical revolution since the Wright Brothers first sustained heavier-than-air flight. Sizable expenditures of money and manpower in applied aerodynamic research, especially in the creation and operation of wind-tunnel facilities, have resulted in practical supersonic configurations compatible with existing gas turbines. Thus the demands for improved structures have increased rapidly since World War II."

Professor Bisplinghoff named three general objectives of the nineteenth annual lecture: to review some of the demands of flight up to appreciable supersonic Mach Numbers on aircraft structures; to discuss ways of meeting these demands; and to assess, at least qualitatively, their influence on design. The problems discussed, he said, are representative of those that will be encountered by manned aircraft within the next 10-year period.

The Wright Brothers Lecture was repeated by Professor Bisplinghoff in Seattle, Los Angeles, and Cleveland. The complete paper will be published in a forthcoming issue of the JOURNAL OF THE AERONAUTICAL SCIENCES.

F-101A

AIR FORCE
U.S. AIR FORCE

IAS Day at Wright-Patterson AFB

Corporate Member Representatives Receive Briefing on Present and Future Air Force Plans
Brig. Gen. Bryan Discusses ARDC Program

One hundred twenty-three security cleared representatives of IAS Corporate Member companies spent the days of November 9 and 10 on one of the most interesting and revealing field trips ever conducted by the Institute. The 2-day program, held at ARDC's Wright Air Development Center, near Dayton, Ohio, included visits to the Center's various laboratories, as well as flight demonstrations of all current USAF aircraft.

The entire program was designed to give this select group a comprehensive picture of present Air Force developments and research trends for the future. Its primary objective was to reveal some of the problems and to invite industry's cooperation in the solution of these problems.

As WADC Commander, Brig. Gen. Thomas L. Bryan, Jr., said in his dinner address before this audience on the evening of November 9, "The Institute of the Aeronautical Sciences has long been a full working partner in what we of the Air Force have done in the past and hope to do in the future. . . .

"I am sure you need no reminder from me of Soviet Russia's growing technical capability and her tireless efforts to overtake us in air power. Nor do you need any reminder of the increasingly more complex technical requirements we face in the battle for air superiority as a result of our own aeronautical advances. Each problem we solve generates a host of new problems. . . .

"For our part [ARDC] we have studied the technical problem of today and tomorrow from every conceivable angle. . . . We feel that we have found the answer in our present ARDC program."

General Bryan then went on to outline the manner in which ARDC has adopted a "bifocal approach to the research and development problem," with a short-range *Operational Program* and a long-range *Technical Program.*

"The first area," he said, "the *Operational Program,* represents the work we do on weapons which the Air Force will use or start to use in the immediate future or any time within the next 7 or 8 years. It includes the development management of complete weapon systems and the development engineering of all the equipment to go into these systems. It also includes the development of operational support items that are not tied to any one weapon system, such as crash trucks, parachutes, etc. Each item within the Operational Program has a definite date of entry into the Air Force inventory and, in general, uses techniques already demonstrated.

"Our long-range look . . . is our *Technical Program.* It is made up of two areas. The first is *Research,* which seeks new basic knowledge in the fields of interest to the Air Force. The second is *Technical Development,* or *Exploratory Development,* which seeks to discover how to use this knowledge and transforms it into experimentally demonstrated techniques. These techniques or capabilities can then be siphoned off and applied to the design of actual hardware to fulfill specific needs of the operational commands. Technical Development, I may emphasize, is aimed at providing the weapons that will be needed 10 to 15 years in the future.

"Basically, then, in the area of Technical Development, Research gives us the know-why and Exploratory Development the know-how.

"It is the area of Exploratory Development in which we must obtain the techniques and capabilities to enable us to put our future air weapons into being. It is the real pay-off area in which all of us must work together on achieving really significant gains for much greater performance rather than on making modest improvements on what we already have.

"Today, major technical advances—let us call them break-throughs—are vitally needed in many development areas, particularly in the design of new research aircraft for exploring boundary-layer control, vertical take-off, and the high-temperature effects on structures. Also urgently needed are advances in

(*Below*) Group assembled in WADC auditorium for general briefing. (*Opposite page*) Reviewing stands erected in mid-field for flight demonstrations followed by a static display and inspection of all aircraft on the flight line.

the exploitation of specialized power plants, in the solid-state physics art, and in high-resolution radar. . . .

"What we have done for our technical program is to organize the entire field of air research and development into 46 broad, functional areas, such as Strategic Bombing, Communication, Navigation, Active Bomber Defense, etc. And we have prepared a staff study around each area. This staff study is called a 'Technical Program Planning Document.'

"Each of these Documents does four important things:

"*First*, it states and defines the military job the Air Force will have to do some 10 to 15 years in the future in the particular area covered.

"*Second*, it evaluates our present technical capability in the area and points out the limitations of our current materiel and techniques. It serves to advise us, in other words, just how far we are from solving the military job to be done.

"*Third*, each Document presents, for thought-stimulation purposes only, pertinent research summaries, preposed innovations, and suggestions regarding avenues of approach.

"And *fourth*, it presents our Technical Requirements which explicitly spell out desired performance objectives. There is on the average of three Technical Requirements to each Document, and they essentially tell us what we have to do from the technical standpoint to close the gap between the Air Force's future military job and our present technical capability. . . .

"At the present time, the machinery already is in operation to release our Technical Program Planning Documents outside the Air Force for the first time.

"You may not realize it, but the job of getting the Documents in the hands of Science and Industry is far from a simple one. It is complicated by all kinds of detailed problems, and it is something that is going to require—and I am sure it will receive—a large amount of tolerance, patience, and understanding from all of you. . . .

"As it now stands, we are in the first or trial stage of a three-phase operation that will give Science and Industry access to our basic requirement and planning information. . . ."

General Bryan went on to say that an initial list of Air Force contractors had been advised of the plan and that the response had been enthusiastic. He described the machinery for handling the distribution of the Documents and indicated that the second phase of the operation would encompass several hundred more Air Force contractors.

"As a fortifying supplement to the first and other phases of our plan to keep Science and Industry informed of our requirements and objectives," he continued, "we are also sponsoring a series of Technical Program Symposia. Through these symposia we hope to bring together the ARDC research and development planners and programmers with the engineers and scientists of such organizations as receive the Technical Program Planning Documents. . . .

"By July of 1956 we expect that the seven divisions of our Directorates of Development will have conducted seven such symposia in various cities of the United States, thus covering all 46 areas of air research and development. And, as this program of symposia is intended to be repeated annually, at least the coordination of our dynamic problem will be approached in a dynamic manner. . . .

"Finally, as a continuation of the program, we propose to inaugurate the third phase of our plan. Following an appropriate announcement in trade journals and other publications, the Air Research and Development Command will be prepared to receive queries and requests from potential sources of research and development, representing organizations that are not now Air Force contractors.

"It is in this third phase of our plan that we expect to realize some of the greatest gains, by tapping the very roots of American science and technology. We feel sure that in the final release, a number of new firms and laboratories will be reviewed and cleared to join the team, thus expanding our foundation of research and development and insuring that all of the team members are working in the same direction with consistent terms of reference.

"To avoid any misunderstanding regarding this third phase of our operations, I would like to point out that the Technical Program Planning Documents being released bear various security classifications, depending naturally on their content. If a prospective recipient of the Documents does not have a Secret clearance, he may still receive Documents of a lower security level, equal to the clearance he does possess. The Technical Program Symposia, however, have been and are expected to continue to be on the Secret level.

"Any questions you may have regarding this third phase, or any others relative to this program, I may add, should be directed to the Commander, Air Research and Development Command, P.O. Box 1395, Baltimore 3, Md. Attention: RDTDD, Development Plans & Programs, Director of Development. . . .

"Now what does this release program mean to you and to us?

"From a legal standpoint, if you are a recipient of the Documents, you are assured that they are furnished to you only for information and guidance. In short, there is no obligation on your part to submit proposals in return for getting the Documents. Nor do they represent any commitments on the part of the Government.

"From a technical development standpoint, the Documents acquaint you with our present capabilities and our future technical requirements and generally provide you with a working concept of what the Air Research and Development Command is attempting to achieve in the development of superior air weapons.

"In plain talk, we also hope that you of Science and Industry—fortified with our requirements and objectives—will take a more active part in exploratory development and support more of it from within your own resources. What we seek and urgently require, I repeat, are new techniques and capabilities—the know-how—which will give us really significant gains rather than modest improvements. . . .

"We are convinced that by giving you the whole technical picture, you will voluntarily start to take on more independently supported exploratory development and to fire in proposals as soon as you have something you feel will give us the big jumps we need. . . .

"I certainly hope that our program will be a two-way operation. Not only do we want to get our plans and requirements to you but we want your ideas. Above all, we want you of Science and Industry to feel free at any time to offer constructive comments on our plans."

Members of the Dayton Section joined the group at the "open" dinner, and some 400 guests heard General Bryan speak. IAS President Robert E. Gross was on hand to extend the Institute's thanks to the Commanding General and his staff at WADC, to ARDC, and to the officers and members of the IAS Dayton Section who cooperated in making this an outstanding meeting.

Ten IAS Members Named "Elder Statesmen of Aviation"

Ten members of the IAS are listed in a group of 15 "Elder Statesmen of Aviation" elected by the Board of Directors of the National Aeronautic Association. The Elder Statesmen were guests of honor December 17 at the annual Wright Memorial Day Dinner in Washington, D.C., sponsored by the Aero Club of Washington.

The purpose of establishing a list of Elder Statesmen, the NAA said, is to honor outstanding living Americans (over 60 years old) who, by their efforts over a period of years, have made contributions of significant and enduring value to aeronautics. To start the new group, 15 men were chosen in the latter part of 1955. Five additional members will be elected in 1956 and again in 1957, and three will be added each succeeding year.

Those who attended the dinner were presented with engraved testimonials. Names of all the Elder Statesmen will be engraved in bronze and appropriately enshrined, the committee said.

One of the men chosen, Glenn L. Martin, an Honorary Fellow and Past President of the IAS, died within a month after being notified and before the certificates were awarded. Mr. Martin, who built a biplane in 1909 and taught himself to fly, was identified by the NAA as "the senior living contemporary of the Wright brothers." He was credited with giving "a fortune" of several millions to the University of Maryland for its College of Engineering and for aeronautical research. The award recognized his many previous honors as an aviation pioneer and aircraft builder.

The other IAS members named as Elder Statesmen, and some of the reasons advanced by NAA for their selection, were:

WILLIAM F. DURAND, retired aeronautical scientist and Honorary Fellow of the IAS, who lives in Brooklyn, N.Y., and Palo Alto, Calif. He developed basic propeller theories and was for years the foremost authority on air propellers; laid foundation for American aeronautical science; assisted in establishment of the National Advisory Committee for Aeronautics and served as its Chairman during World War I. He was called from retirement at age 82 to organize production of jet-propulsion engines in America during World War II.

LESTER D. GARDNER, Founder of the IAS and an Honorary Fellow, who lives in New York. He brought about the first restoration of the original Wright Kitty Hawk airplane; established the IAS Aeronautical Archives; and assisted in founding the NAA, Aircraft Manufacturers Association, and international aviation groups.

JEROME C. HUNSAKER, First President of the IAS and an Honorary Fellow, of Cambridge, Mass. He built a pioneer wind tunnel and organized the first course in aeronautical engineering in America; taught aeronautical engineering for many years at Massachusetts Institute of Technology; and has been Chairman of the NACA since 1941.

BRIGADIER GEN. FRANK P. LAHM, USAF (Ret.), MIAS, of Huron, Ohio. He was the first Army pilot taught to fly by the Wright brothers; won the first Gordon Bennett Balloon Cup Race, 1906; organized Army aviation training; and was Assistant Chief of the Army Air Corps.

VICE-ADM. EMORY S. LAND, USN (Ret.), FIAS, of Washington, D.C. He devoted 35 years of active duty to U.S. Naval Aviation; was Vice-President and Treasurer of the Daniel Guggenheim Fund for Promotion of Aeronautics; and was Vice-President of the Air Transport Association from 1946 to 1954.

PAUL W. LITCHFIELD, AMIAS, of Akron, Ohio, who supervised design and construction of military training balloons and airships for service in World War I; built the naval airships "Akron" and "Macon"; and directed Goodyear Aircraft Corporation production in World War II.

GROVER LOENING, FIAS, of Mill Neck, N.Y., who was the first aeronautical engineer of the U.S. Army; pioneer designer and builder of seaplanes; and promoter of air cargo. He wrote a special report on aircraft and the merchant marine and served the Government in many ways, particularly as a Consultant to the 1947 President's Air Policy Commission, the NACA, and the Secretary of Defense.

WILLIAM P. MACCRACKEN, JR., MIAS, pioneer aviation attorney, of Washington, D.C. He presided at the organization of the NAA in 1922; was Chairman of the Committee on Aviation Law, American Bar Association; was the first Assistant Secretary of Commerce for Aeronautics and represented the U.S. Government at numerous international aviation conferences.

IGOR I. SIKORSKY, IAS Honorary Fellow of Bridgeport, Conn. Born in Russia, he was a pioneer pilot and a pioneer designer and builder of airplanes and helicopters, beginning in 1909; built the world's first four-engined airplane; produced one of the earliest successful transport planes, and designed and produced the first successful American helicopter.

The idea of naming Elder Statesmen of Aviation was attributed to John F. Victory, MIAS, Executive Secretary of the NACA, who is Vice-President of the NAA.

C. C. Furnas Appointed to Defense Post

Clifford C. Furnas, FIAS, Chancellor of the University of Buffalo, has been appointed Assistant Secretary of Defense (Research and Development) by President Eisenhower. He assumed the post December 5, succeeding Donald A. Quarles, who became Secretary of the Air Force on August 17. Dr. Furnas is on leave of absence from the University.

From 1946 to 1954, Dr. Furnas was Director of Cornell Aeronautical Laboratory, Inc., Buffalo. He was the Laboratory's first Director and had previously been Director of the same research laboratory when it was operated by the Curtiss-Wright Airplane Division.

Dr. Furnas has previously served the Department of Defense research and development organization in a consultant capacity and had been associated with its predecessor, the Research and Development Board, in various capacities since February, 1948. Until recently he headed the Technical Advisory Panel on Aeronautics. Prior to that he was Chairman of the Committee on Guided Missiles and a member of the Committee on Aeronautics of the Research and Development Board.

During World War II, Dr. Furnas served with groups of the National Defense Research Committee of the Office of Scientific Research and Development which were concerned with physical, chemical, and chemical engineering problems.

By virtue of his new position, Dr. Furnas automatically became a member of the National Advisory Committee for Aeronautics. When appointed, he was a member of its Committee on Aircraft Construction.

Sandberg-Serrell Corporation Joins the Institute

Another new Corporate Member of the IAS is the Sandberg-Serrell Corporation, consulting engineers, of Pasadena, Calif. This company is engaged primarily in the design of wind tunnels and aerodynamic research equipment. Founded in 1948, it specializes in the solution of unusual structural and mechanical design problems.

As examples of its work in the aeronautical field, Sandberg-Serrell Corporation lists flow channel aerodynamic design, vibration analysis, servo design and analysis, gearing and linkages, structures designed for low deformation, and structures designed to avoid or minimize thermal stresses and deformations.

At the USAF's Arnold Engineering Development Center, Tullahoma, Tenn., Sandberg-Serrell designed a 16 by 16-ft. Mach 1.6 flexible nozzle and test section for the transonic wind tunnel; a 16 by 16-ft. Mach 4.5 flexible nozzle for the supersonic tunnel; and a 4 by 4-ft. quickly variable Mach Number nozzle for the ram-jet facility.

One specialty has been the design of force-measuring systems and calibration apparatus. The company has designed and furnished six-component internal-strain-gage balance systems for a number of wind tunnels. Recently, a strain-gage balance was designed and manufactured to measure aerodynamic and acceleration forces on a missile while it is attached to a parent aircraft.

Wind-tunnel balances require an extremely accurate calibration system. The company recently designed and furnished a six-component loading system for calibrating strain-gage balances at Ames Aeronautical Laboratory, NACA, Moffett Field, Calif.

Hyatt's Award Not for VTO

Abraham Hyatt, AFIAS, Director of the Research Division of the Navy Bureau of Aeronautics, reports that the Distinguished Civilian Service Award he received recently (see AERONAUTICAL ENGINEERING REVIEW, pp. 21, 22, December, 1955) was for a contribution that is still highly classified and not in any way related to the Navy's VTO aircraft.

Necrology

Edward W. Breen

Edward W. Breen, TMIAS, an Aerodynamicist with Grumman Aircraft Engineering Corporation, Bethpage, Long Island, N.Y., died of a heart ailment October 30. He lived in East Patchogue, N.Y.

A graduate of Rensselaer Polytechnic Institute in 1954, Mr. Breen had held a Grumman Aircraft scholarship and worked at the plant as an engineering apprentice for four summers. He majored in Aeronautical Engineering and was elected to Sigma Xi.

Richard J. Hruda

Richard Joseph Hruda, MIAS, of Burbank, Calif., was killed November 17 in an airplane accident near Las Vegas, Nev. He was a Structural Engineer with Lockheed Aircraft Corporation and a graduate of Illinois Institute of Technology, where he studied Civil Engineering. Mr. Hruda, who was 37 years old, leaves his wife, Grayce.

Bernard L. Mock

Bernard Lee Mock, MIAS, Senior Engineer at Marquardt Aircraft Company, Van Nuys, Calif., died on October 19. He had been in poor health for some time.

Born in Zanesville, Ohio, in 1915, he received his B.S. in Aeronautical Engineering at the University of Michigan. After service in the Naval Reserve he joined the Columbus Division of Curtiss-Wright Corporation.

In 1948 Mr. Mock joined Marquardt Aircraft Company, where he was credited with several significant contributions to the design of ram-jet and turbojet engines. One example was his development of a method for optimizing the installation design of a supersonic afterburning turbojet engine which minimizes the requirements for mechanically varying the duct-engine geometry. The design involves a high pressure-recovery supersonic inlet and a combination ejector-cooling shroud and variable-area exhaust nozzle.

Mr. Mock is survived by his wife, the former Marjorie Gosnell, and three children.

André A. Priester

André A. Priester, FIAS, Vice-President of Pan American World Airways, Inc., died on November 28 in Paris, France, where he was attending a meeting of the Technical Committee of the International Air Transport Association. He was 64.

Born in the Netherlands East Indies, Mr. Priester served with the Royal Netherlands Army in World War I and learned to fly after the war ended. He began his aviation career in 1920 with KLM Royal Dutch Airlines and within 6 months became Assistant Operations Manager. During 5 years with KLM, he became increasingly aware of the possibilities of long-distance, international air transport.

He came to America in 1925 as Air Transport Engineer of the Atlantic (Fokker) Aircraft Corporation, Hasbrouck Heights, N.J., and a year later became Assistant Operations Manager of the model air line set up between Philadelphia and Washington in connection with the Sesquicentennial Celebration in Philadelphia.

In the course of these duties he met Juan T. Trippe, who was then organizing Pan American Airways, and he joined P.A.A. as Chief Engineer in charge of Operations and Maintenance prior to the inaugural flight.

In 28 years with the company, Mr. Priester was credited with substantial contributions to many of the outstanding technical developments in civil aviation, such as four-engined aircraft, more efficient power plants and fuels, radio communications and navigating aids, and long-range cruising techniques for over-ocean flight. He played a leading part in the development of many commercial air transports from the Fokker F-7 and F-10, the Ford Trimotor, and the Sikorsky S-38 to the Boeing Stratocruiser. More recently he had been concerned with the technical aspects of jet transport development.

Mr. Priester lived in Douglaston, N.Y., and is survived by his wife, Sylvia De Haan Priester. Burial was in Chula Vista, Calif.

Paul D. Smith

First Lt. Paul D. Smith, USAF, TMIAS, of Midland, Tex., was killed October 15 in a flight from Los Angeles to Yuma, Ariz. After graduating from the University of Texas in 1954 with a B.S. degree in Aeronautical Engineering, he had joined the Air Force and qualified as a pilot.

Robert K. Souter

Robert Kimble Souter, AFIAS, died at his home in Bel Air, Md., on November 18. He was with the Test Division, Chemical and Radiological Laboratories, Army Chemical Center.

A graduate of Rensselaer Polytechnic Institute, where he majored in Aeronautical Engineering, Mr. Souter worked for Pan American World Airways, Inc., as a Meteorologist and then, in 1940, joined the NACA as an Aeronautical Engineer and Meteorologist at Langley Laboratory. In 1951 he became a civilian employee of the Air Force. He was an Operations Analyst in a scientific advisory group attached to Headquarters, Tactical Air Command, Langley AFB, Va.

He was a member of the American Meteorological Society, American Association for the Advancement of Science, American Geophysical Union, Arctic Institute of North America, Mt. Washington Observatory Corporation, Engineers Club of the Virginia Peninsula, and U.S. Naval Institute.

Mr. Souter, who was 39 years old, leaves his wife, Marjorie.

Paul G. Weiller

Paul G. Weiller, MIAS, President of Weiller Instruments Corporation, New York, died on November 2. A metallurgical engineer, he was born in Trieste, and was educated in Vienna and Berlin. He obtained his Doctor of Engineering degree in 1908 at Technische Hochschule, Charlottenburg, Berlin. Dr. Weiller was formerly with Kollsman Instrument Corporation. He is survived by his wife, Martha.

J. L. Atwood, FIAS, President of North American Aviation, Inc., has been honored by the Republic of Italy with the Commander of Merit decoration for his "personal contributions to the aviation industry."

NEWS OF MEMBERS

▸ **Malcolm P. Ferguson** (AM), President of Bendix Aviation Corporation, has been named to the Executive Committee of the Aircraft Industries Association.

▸ **George T. Hayes** (TM), Manager of the Washington office of Stanford Research Institute, has been appointed Chairman of the Executive Committee of the Aviation Division, American Society of Mechanical Engineers.

▸ **Dr. Barry G. King** (M) of CAA's Medical Division, Office of Aviation Safety, has received an award from the Flight Safety Foundation for "distinguished service in achieving safer utilization of aircraft." He was cited for his work on emergency evacuation.

▸ **Cramer W. LaPierre** (M), Vice-President of General Electric Company in charge of the Atomic Energy and Defense Products Group, has been elected Chairman of the Board of Governors of the Aircraft Industries Association for the first half of 1956. He also was chosen Chairman of the Eastern Aircraft Manufacturers Council for 1956.

▸ **John B. Nichols** (M), Chief Research Engineer of Hiller Helicopters, received The Spirit of St. Louis Junior Award at the last annual meeting of the American Society of Mechanical Engineers. The recognition was for his paper entitled "An Energy Basis for Comparison of Performance of Combustion Chambers."

▸ **Frank N. Piasecki** (F), helicopter pioneer, has been made an Honorary Member of Tau Beta Pi Fraternity at New York University.

▸ **T. Claude Ryan** (M), President of Ryan Aeronautical Company, has been appointed to the Finance Committee of the Aircraft Industries Association.

▸ **R. Dixon Speas** (AF), Aviation Consultant, has written a book entitled *Principles of Air Transport Management*, published by McGraw-Hill Book Company, Inc.

Members on the move . . . .

This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.

Norman J. Asher (M) has joined Piasecki Helicopter Corporation as Administrator for Research and Preliminary Design. He was formerly an aeronautical research engineer in the Office of Naval Research, Washington, D.C.

Gabriel D. Boehler (M) has joined the staff of Catholic University of America, Washington, D.C., as Assistant Professor of Aeronautical Engineering. He continues temporarily on the engineering staff of Thieblot Aircraft Company, Inc.

William H. Dorrance (M) has been named Assistant to the Director of Scientific Research of Convair, A Division of General Dynamics Corporation. He was formerly Supervisor of a Missile Aerodynamics Group in the Convair (San Diego) Engineering Department.

T. A. Feeney (M) has been elected a Vice-President of Coleman Engineering Company, Inc. Formerly Technical Director, he will have charge of technical planning.

J. C. Garrett (M), President and Founder of The Garrett Corporation, has been elected its Chairman of the Board.

Daniel E. Harrison (M), formerly of Goodyear Aircraft Corporation, has joined the engineering staff of the Applied Physics Laboratory of The Johns Hopkins University, Silver Spring, Md.

Rear Adm. Lloyd Harrison, USN (AF), who joined McDonnell Aircraft Corporation August 1 as Vice-President for Procurement, has been elected to the Board of Directors. He was formerly Assistant Chief of the Navy Bureau of Aeronautics.

(*Continued on page 58*)

Edwin A. Speakman, AFIAS, General Manager of Fairchild's Guided Missiles Division, has been named Chairman of the Guided Missiles Committee of the Aircraft Industries Association.

Editorial

Glenn L. Martin, 1886–1955

With the passing of Glenn Martin, aviation in America lost one of its pioneer builders and the Institute lost one of its great and good friends.

Lester Gardner, IAS Founder and long an associate of Glenn Martin, writes, "The Institute has lost a valued friend who gave it his encouragement when it was organized and did all he could during his lifetime to assist in its growth. . . . When the history of the Institute is finally written, the part he played in it will be most significant. . . . Whenever there was a need for funds, Mr. Martin was always one of the first donors. . . . From the earliest years to the time of his death, of the various funds he established in memory of his mother, The Minta Martin Aeronautical Student Fund is among the largest endowed memorial in the hands of any of the engineering or scientific societies."

One of Mr. Martin's original contributions (circa 1940) was in the form of a block of his company's stock originally intended to help support an Aero Medical Research Laboratory on the former Daniel and Florence Guggenheim estate at Sands Point, L.I. (a gift to the Institute of the Guggenheim family). This project was never carried out because of the pressures of the war. Some years later—after the Navy had purchased the Sands Point property for the Special Devices Center—a portion of the original Martin gift was set up as The Minta Martin Aeronautical Student Fund. As has been reported in newspapers, this fund has been further augmented under the provisions of Glenn Martin's will.

The Minta Martin Aeronautical Student Fund was first announced in the August, 1954, issue of the REVIEW (p. 26). At that time Mr. Martin said, "The establishment of this fund is in keeping with the ideals of my late mother, Minta Martin, who from the beginning demonstrated a great interest in young people in aviation. By making this fund available to the Institute of the Aeronautical Sciences, its efforts in preparing the student engineer for his place in the aeronautical industry will be facilitated. It is my hope that this fund will benefit aeronautical students throughout our country for many years to come."

With the augmented fund now provided by Mr. Martin's will, the Institute will be in a position to carry on this most important activity for the indefinite future.

In paying tribute to the memory of one of aviation's great pioneers, and to his mother who lent invaluable encouragement to him in his early struggles, the IAS expresses its continuing appreciation to one who was a real benefactor to this organization, a past president, and a great American.

S. P. J.

Glenn L. Martin, aviation pioneer, Honorary Fellow, Founder Member, and Benefactor of the IAS, died in Baltimore on December 4 at the age of 69. Winner of the Collier Trophy, the Guggenheim Medal, and many other honors, he served as president of the Institute in 1936. He delivered the 1953 Wright Brothers Lecture marking the fiftieth anniversary of powered flight. In 1954, Mr. Martin established and endowed the Minta Martin Aeronautical Student Fund, which is administered by the Institute to encourage aeronautical engineering education.

Richard R. Carhart*
Lockheed Aircraft Corporation

Growing a Reliable Missile

A suggestion for more subsystem testing and evaluation, along with component improvement, as a means of achieving overall system reliability.

Introduction

We like to think that guided missiles are designed, then built according to the design, and finally tested to prove the design. Actually, guided missiles are not built; they are grown. By saying they are grown, I mean that the design is a preliminary plan to start the development process; but it is only a beginning. As the development proceeds, the design of the parts and their interactions in the system are continually modified by testing and evaluation, until the system requirements are finally met. This is a growth process.

Fig. 1 shows the growth of reliability for a hypothetical high-reliability missile. The development period lasts about 8 years, at which time production flight testing is started. During development some 150 missiles are flight-tested, and the reliability grows from 20 per cent early in the program to 90 per cent by the eighth year.

The corresponding reliability effort at the component, subsystem, and system levels is shown schematically. At present, there is much reliability testing going on at the component level. This work is vital and must be expanded to improve component reliability. On the other hand, at the system level, there is recognition of need for early flight testing to provide realistic environmental data and for flight tests later in the program in order to evaluate the system reliability. But between these two, at the subsystem level, there is need, I believe, for more reliability work and for better understanding of the role of subsystem testing in reliability.

Purpose

The purpose of this paper is to examine the basic concepts of component reliability, to indicate the limitations in the component approach, and finally to suggest that more reliability effort be focused at the subsystem level in order to bridge the gap between component testing and system reliability.

System

A guided-missile system is an assembly of interacting components and subsystems assembled to perform a military mission. By "components" I mean resistors, tubes, valves, motors, gyros, and other parts or assemblies. By "subsystems" I mean the major functional assemblies—namely, the propulsion, control, guidance, fuzing, and warhead. In a typical missile, there are of the order of 1,000 components and about 10 subsystems.

Two characteristics of missile systems are important for reliability. The first is that you do not have a system unless the parts *interact* to perform the task. This interaction is essential. It is what makes the system more than merely the sum of its parts. The second point to note is that the system is built for a purpose; it has a reason for existing, a *mission*, and this leads us to reliability and accuracy.

Missile Reliability and Accuracy

Consider a missile which is being developed for operational use against an enemy ground target. It has a military mission to deliver a warhead with a specified accuracy and reliability. For example, the accuracy required might be a CEP† of 1 mile—i.e., half the hits should fall within a mile of the target center. The reliability required might be 90 per cent. What do these requirements of accuracy and reliability mean, and how are they related?

The classical approach assumes that there are two kinds of missiles, good missiles and bad missiles. The good missiles are those in which the parts, components, and subsystems all function more or less within their design tolerances, so that the missiles fall in a pattern around the target. The bad missiles, on the other hand, suffer malfunctions which cause the missile to abort.

The *accuracy* of the missiles is then measured by the CEP of the good missiles—i.e., the radius within which half of the good missiles hit. If this CEP is 1 mile or less, the accuracy requirement has been met. The *reliability* of the missiles is the good fraction of all the

* Department Engineer, Staff Technology Department, Missile Systems Division.

† Circular Error Probable.

missiles fired. Thus, if 90 per cent of the missiles are good and 10 per cent abort, the requirement of 90 per cent reliability has been met.

Now this all sounds simple and clear, and it allows reliability and accuracy to be treated as two distinct concepts. In fact, one can imagine a missile having a high accuracy and a low reliability! Moreover, as long as the missiles can be clearly split into goods and bads, it gives a way of measuring both accuracy and reliability by statistical means.

But now we must face up to this assumption that we can separate the reliable sheep from the unreliable goats. Suppose we are given the results of 100 test missiles fired on a range. Can we divide the missiles into goods and bads? There is no question about the 20 missiles that explode on the launching rack, or break up in boost, or do not lock onto their guidance signals and land 50 miles away in the wrong direction. They are all obviously bad missiles, total failures, aborts.

Nor is there any question about the 60 missiles that impact within a mile or so of the target—they are pretty clearly good missiles for they have performed with about the required accuracy.

But this only accounts for 80 of the 100 missiles. What about the other 20 that are scattered all over the desert, from 2 or 3 up to 5 or 10 miles from the target? How do we decide which of these are good missiles but near misses, and which are bad missiles but near hits? In other words, how do we handle the marginal performers?

We clearly need some kind of decision procedure, some rules for deciding which missiles are good and which are bad. In other words, we need to state performance limits such that missiles falling outside these limits are called bad or unreliable, and those falling inside are called good or reliable. Establishing these limits is not easy, and the question deserves careful consideration for it goes to the heart of the problem of reliability requirements and evaluation. I believe that such limits can and must be set, however, if test flight reliability is to be clearly defined and measured.

These remarks can be summarized in two conclusions:

(1) Reliability and accuracy are separate concepts so long as we are dealing with clear-cut good or bad missiles; but, between the white goods and black bads, there are grey marginal missiles, and in this grey area reliability and accuracy considerations overlap. They both deal with the distribution of system performances.

(2) If we are clearly to define and measure reliability and accuracy, we can and must set arbitrary limits somewhere in this grey area, limits which will define what we mean by good and bad missiles.

Now let us ignore the accuracy problem and turn to the question of reliability.

Reliability

A basic definition of reliability which has been widely accepted is the following:

The reliability of an item is its probability of success in performing a specified *task* for a given *operating time* under the operational environment.

The four key elements in the concept are reliability, task, operating time, and environment.[1] All four must be specified in stating *reliability requirements*. The operating time and the environment are important parts of the test conditions under which reliability is measured, for reliability decreases with longer operating times and more severe environments. The task states the performance requirements which define satisfactory functioning. The task may refer to any phase in the use of the device, and the choice of the task determines what kind of reliability we are considering. Thus, we may have *storage reliability* for the probability that the item will be usable after a period of storage, or *test reliability* for the probability that the item will pass a given test.

Mission Task

For a missile system the task is normally called the military mission. The *mission task* for a system can usually be specified in terms of performance and operating conditions—i.e., definite limits of performance, space, and time, within which the system is successful and outside of which it fails. This is shown schematically in Fig. 2, where P shows the performance spread—e.g., miss-distance—and T is the task—the target size—the mission being to strike the specified target. The mission reliability for the system is then the probability that the missile performs this task successfully. In general, of course, the performance is specified by a set of parameters rather than one variable. The task is likewise specified by a corresponding set of parameter limits, so that each parameter in P is matched by its limits in T. These considerations provide an operational definition of system reliability.

Turning now to component reliability, we must distinguish between two kinds of components, *independent components* and *dependent components*. The distinction is important, for, as I shall try to show, the well-known product rule relating component reliabilities to the system reliability is valid and accurate for independent

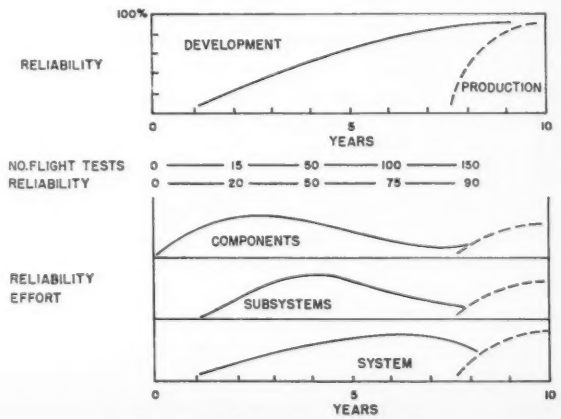


Fig. 1. Missile reliability growth.

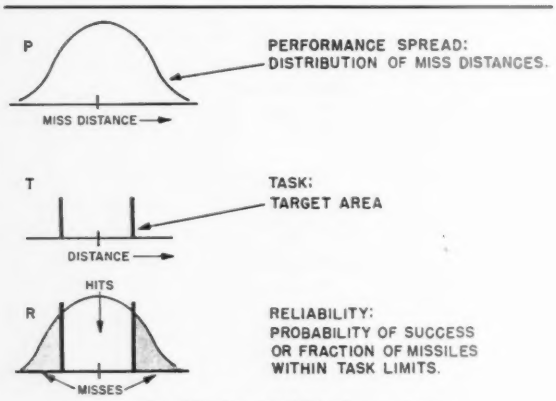


FIG. 2. Mission reliability for a system.

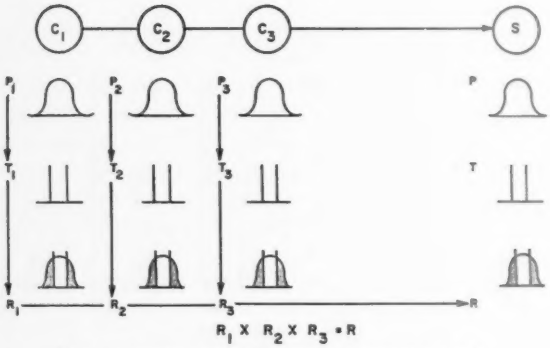


FIG. 4. System reliability using the product rule.

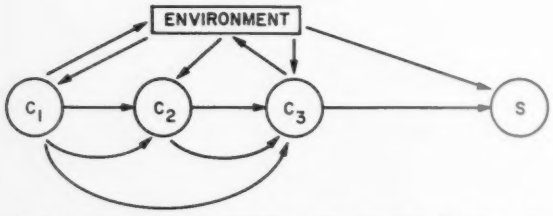


FIG. 6. Dependent components have any or all of the following characteristics: functional interaction with the rest of the system, environmental interaction with the rest of the system, and/or task compensation interaction with the rest of the system, so that the component reliability is dependent on the reliabilities in the rest of the system and is statistically correlated with them.

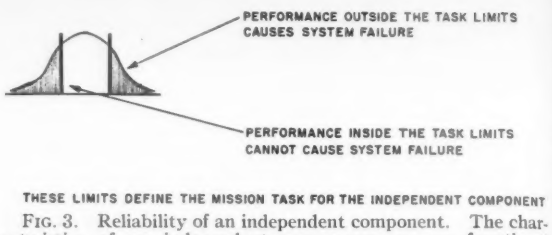

PERFORMANCE OUTSIDE THE TASK LIMITS
CAUSES SYSTEM FAILURE
PERFORMANCE INSIDE THE TASK LIMITS
CANNOT CAUSE SYSTEM FAILURE
THESE LIMITS DEFINE THE MISSION TASK FOR THE INDEPENDENT COMPONENT

FIG. 3. Reliability of an independent component. The characteristics of an independent component are: no functional interaction with the rest of the system, no environmental interaction with the rest of the system, and no task compensation, so that the component reliability is independent of the reliability of the rest of the system.

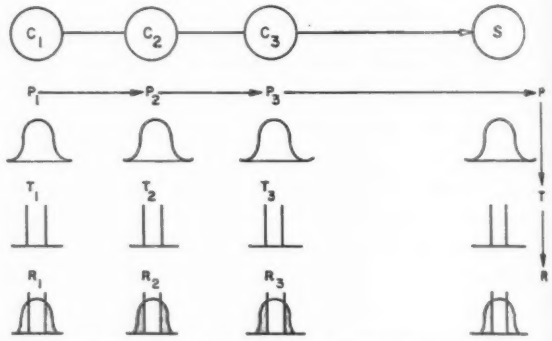


FIG. 5. System reliability using the performance spread method.

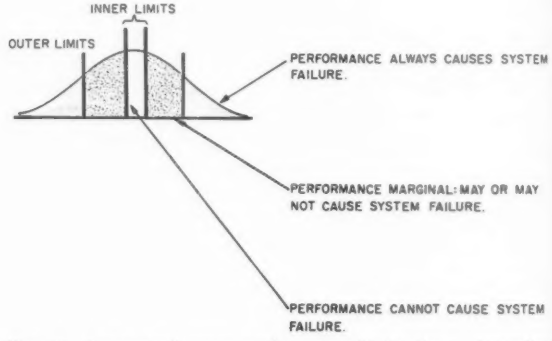

INNER LIMITS
OUTER LIMITS
PERFORMANCE ALWAYS CAUSES SYSTEM FAILURE.
PERFORMANCE MARGINAL: MAY OR MAY NOT CAUSE SYSTEM FAILURE.
PERFORMANCE CANNOT CAUSE SYSTEM FAILURE.

FIG. 7. Inner and outer performance limits for a dependent component.

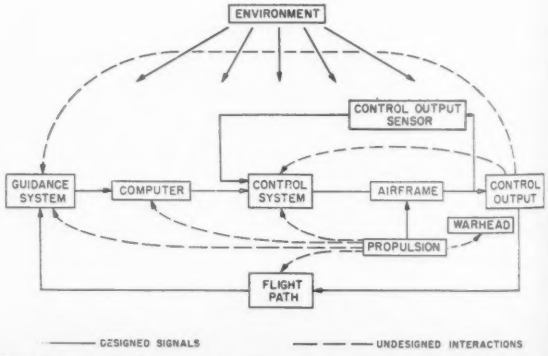


FIG. 8. Typical interaction diagram for missile subsystems.

components but is only approximate and, indeed, incorrect in principle when applied to dependent components.

Independent Components

What do we mean by an independent component? Fig. 3 shows the concept. An independent component is one whose *reliability* is independent of the rest of the system. This means that its performance, environment, and task are all independent—i.e., there is no significant functional or environmental interaction with the rest of the system. In addition there is no task compensation, so that, if the component performs outside its task limits, it causes system failure and cannot be compensated for by another component. Inside these limits, the component cannot cause system failure. These limits therefore define what may be called the *mission task* of the component, and the probability of successful performance is the component reliability.

An example of an independent component is a dry cell battery whose voltage is nearly constant and not affected by other components and the environments.

Predicting System Reliability for Independent Components

For a system of three independent components in series, the system reliability can be calculated in two ways. The first method, shown schematically in Fig. 4, is the *product rule*. For each component, the performance distribution and the task limits are compared to find the successful fraction, or reliability. These component reliabilites R_1, R_2, R_3 are then multiplied together to give the system reliability R.

The second approach is the *performance spread method*, shown in Fig. 5. Here the component performance spreads are first combined to find the system performance spread P, which is then compared with the system task T, to give the system reliability R.

It can be shown that the product rule and the performance spread method are equivalent when the components are independent.

Dependent Components

By a *dependent component* we mean one which interacts in some significant manner with the rest of the system, as shown in Fig. 6. First, it may interact functionally by affecting the performance of another component—for example, a power supply output affects the emission of a tube. Second, there may be environmental interaction, as in the case where the heat from the power supply overheats the nearby tube. Third, there may be task compensation—for example, the power supply output voltage may be too high, but the tube emission may be abnormally low so that it compensates for the high power supply, and the combination of high power supply and low emission is acceptable. Thus, we have a successful combination of two defective components through task compensation. This might be called *positive task compensation* because the system succeeds in spite of poor components. Similarly, we may expect *negative task compensation* in which the system fails in spite of good components because of an unfortunate combination of extreme but acceptable components.

No Mission Task for Dependent Components

We saw earlier that reliability has meaning only when we can distinguish success and failure—that is, when we can state the task. In view of task compensation between dependent components, can mission tasks be defined at all? I believe they cannot. From the system point of view, there are three possibilities for the dependent component—*success*, *marginal performance*, and *failure*—as shown in Fig. 7. Corresponding to these three cases there are *two* sets of performance limits, the inner limits and the outer limits. These limits can be defined as follows:

(1) Component performance outside the outer limits is certain to cause system failure.

(2) Component performance inside the inner limits cannot cause system failure.

(3) Finally, component performance between the inner and outer limits is marginal—it may or may not cause system failure, depending on the interactions and compensations with the rest of the system.

The important conclusion is that *a dependent component has no mission task, no single set of limits outside of which it is certain to cause system failure and inside of which it cannot cause system failure.*

And it follows that, if the dependent component has no mission task, it also has no mission reliability. Mission reliability is a meaningful term for a system or for an independent component; mission reliability has no meaning for dependent components.

Specification Reliabilities

But if mission reliability is not an applicable concept for dependent components, what kind of reliability are we concerned with when we discuss tube, resistor, or autopilot reliabilities?

The answer, I believe, is that where dependent components are involved, we are dealing with what may be called *specification reliability*. This is the probability that the component performance lies within task limits set by a specification.

This *component reliability specification* will include environment and reliability requirements, as well as the task limits. It cannot usually be laid down in final form by the designer, for he has inadequate knowledge. Rather, the specification must be developed as the program evolves.

Early in the program the "model spec." or a "military spec." will be accepted as a first approximation, and isolated component tests will be carried out. As major defects are uncovered, changes will be made both in the component and in the specification. The next stage will be subsystem testing, and this will reveal further defects in the component caused by interactions with other

components. Additional modifications will be made in the component and in the spec. Finally, when subsystem and system testing has shown the component to be acceptable, the specification is judged satisfactory, and it then forms the basis for reliability control of the component during production. In general, this final reliability specification will set task limits which are between the inner and outer limits previously discussed.

Predicting System Reliability from Dependent Components

How can the mission reliability of the system be predicted from the specification reliabilities of the dependent components within the system?

This is an important question because many of the elements in a missile system are dependent, and, early in the program before the system as a whole exists, such a prediction is the only way to establish preliminary component reliability requirements which are compatible with the desired system reliability.

The usual method is to apply the product rule. Because of the interdependence between the components it is clear that the product rule cannot be rigorously valid. Nevertheless, it is the only practical method known, and it provides a first approximation with which to establish requirements and start the component testing program.

How accurate is the product rule? There is only a small amount of data, mostly from tube studies by the group at Aeronautical Radio, Inc., and some from missile studies. These results indicate that the product rule gives a pessimistic prediction for the system reliability.

In one missile study, for example, some 850 components were known to have an average specification reliability of 0.998 at the most. Using this optimistic figure and raising it to the 850th power gave a prediction of 18 per cent. The flight-test reliability of the missile, on the other hand, was 60 per cent so that the product rule prediction was low by a factor of 3.

In one of the Aeronautical Radio examples,[2] the reliability was predicted for a navigation receiver having 29 tubes and operating for 500 hours. Specification reliabilities for the tubes were taken from the manufacturer's life-test data. Using these in the product rule gave a predicted reliability of 23 per cent, as compared with the observed reliability of 75 per cent from flight data. Again the product rule prediction is low by a factor of 3.

The factor of 3 in these examples is probably coincidental, and more studies with good data are needed before the accuracy of the product rule can be judged.

The second approach to predicting system reliability is the performance spread method of combining component performance distributions to predict the system performance spread and then comparing this with the mission task to obtain the system reliability (Fig. 4).

This approach has been explored by several groups and applied to some simplified cases. In general, however, applying this technique to dependent components in a missile system requires design knowledge, which we do not have, concerning environments and component interactions.

Inadequate Design Knowledge

I believe it is important to recognize these limitations in our design knowledge in developing guided missiles. It is clear that, for successful system performance, we must have not only acceptable performance from each component but also satisfactory interactions between the various components. Now, there is at present no way accurately to specify in general how the performance variations of components affect the performance spread of the system. System performance design starts out with bogey or design-center values for all the component performances. Even to discuss reliability we must go further than on-design calculations and consider the effects of off-design values—i.e., variations in the component performances, tolerances, environments, and in the system itself—for no missile system is ever built of components which all have design-center values. It is true that by analytically holding all components on their design centers and then varying one or perhaps two components, a sensitivity or off-design analysis can be made, but this is usually unrealistic and of limited usefulness because we do not generally know the effect of environments on the component performance, nor do we know analytically all the functional interactions between the components being studied. In short, the performance spread method is not practical at present; *we do not know how to predict analytically the performance spread of a complex system in terms of arbitrary performance distributions of the components.*

This means that even the best design cannot alone produce a highly reliable missile system. In addition to good design, an intensive program of testing and modification is also necessary in order to provide the required final design knowledge. Moreover, it is clear that much of this testing must be at the system and subsystem levels in order to provide the more realistic information needed on component interactions, both functional and environmental. Such a program is a trial-and-error process of growth to develop a reliable missile.

What Do We Do?

If these general conclusions are valid, what do we do?

First, we should recognize the limitations of a purely component approach to missile reliability. Component reliability work and the product rule are useful tools in the early stages of a program, but they are only a part of the system reliability program.

Second, we should admit the inadequacy of our design knowledge and recognize that achieving reliability in a complex system is a dynamic trial-and-error process to develop acceptable reliability specifications, both for the component performances under the system environments and also for the component interactions in the system.

Third, we should balance our component efforts by more emphasis on reliability testing and evaluation at the subsystem level.

Subsystem Testing

What are the advantages of subsystem testing?

To begin with, consider the subsystems themselves. In a missile, the major subsystems include the propulsion, air frame and controls, guidance, and the warhead and fuzing, as shown in Fig. 8. These functions factor out of the system in a natural manner for several reasons:

(1) The subsystems have relatively clearly defined input and output functions, usually with design center and tolerances specified.

(2) Each major subsystem tends to be basically distinct from the other parts of the system by virtue of differences in its design, fabrication, and testing.

(3) A major subsystem has a functional unity since the parts and assemblies within this subsystem usually function in a closely related manner to produce the transfer function or perform the task.

These considerations certainly provide good technical reasons for reliability testing of the subsystems as separate entities.

Further advantages become apparent when subsystem testing is compared with component and system testing. Subsystems provide a simpler breakdown of the system to deal with than the multitude of components. There are relatively few interactions between the subsystems, and these can consequently be isolated, reproduced, and studied more easily than can the many component interactions. Input functions are more easily generated, and output functions are more easily measured. Subsystems are smaller, lighter, and easier to test in the laboratory than is the entire system, and they can be tested more rapidly and with more varied environments. The component interactions are also realistically and easily produced when testing is done within the actual subsystem. Similarly, the component environments generated within the actual subsystem are more realistic and more easily produced than when attempts are made to simulate them in testing isolated components. An important feature of subsystem testing is that the components are simultaneously subjected to the common external and internal environments, such as shock, vibration, and temperature, and this leads to more realistic failure rates for the components since these common causes of failure are not artificially isolated and applied separately, as they must be in component testing.

Subsystem testing focuses attention on the question, "Is the component reliable in the system?" rather than, "Does the component pass a specification?," for passing a specification is only a means to gain performance and reliability, not an end in itself. The most frequently failing components in the subsystems can be identified at any stage in the development, and this provides a priority system for concentrating the reliability effort on the most critical component problems. In addition, since there are only about 10 subsystems, the subsystem reliability requirements are much lower than for the several thousand components. Thus for a system reliability of 90 per cent, the subsystems failure rate must be about 1 or 2 per cent, as compared with an average failure rate of only a hundredth of 1 per cent (or 1 in 10,000) for the 1,000 components. These lower reliability levels required for the subsystems mean much smaller samples and shorter testing times than for the components. Subsystem life tests can be run in reasonable times, say 100 hours, as compared with the impractical test periods of several thousand hours required to life-test individual components which necessarily have much longer mean lives than the subsystem. These shorter testing times lead to more rapid and realistic evaluation of the component reliabilities and more effective and economical use of test facilities, since they are now being used to test many components simultaneously.

These are all reasons in favor of more subsystem testing in guided-missile reliability programs, but it should be emphasized that subsystem testing cannot *replace* component testing and modification. After defective components are isolated from the subsystem, they must be studied, tested, and modified, and then tested again in the subsystem. Thus, component testing and subsystem testing are complementary parts of a balanced reliability program. In general, I view the subsystem testing as primarily concerned with realistic *evaluation* of reliability, while component testing results in modifications to *improve* reliability. The subsystem evaluation guides the component improvement effort by assigning priorities to the most important component problems.

Conclusion

This closed loop of activities between testing and evaluation at the subsystem level, and modification and improvement at the component level, is a *reliability cycle.* It involves learning, error assessment, and error reduction by feedback loops leading to readjustment of component reliability requirements and improvements to meet these requirements. In short, the reliability cycle of subsystem evaluation and component improvement is part and parcel of the dynamic process of growing a reliable missile.

References

[1] Carhart, Richard R., *Reliability in Guided Missile Systems,* Aeronautical Engineering Review, Vol. 12, No. 2, February, 1953.

[2] *A Preliminary Study of Equipment Reliability,* Aeronautical Radio, Inc., March 15, 1955.

A review of the development of a high-strength, heat-resistant core material that can be foamed in place, with a brief description of the foaming process.

Materials and Fabrication Techniques for Structural Heat-Resistant Plastic Sandwiches

Norman E. Wahl*
Cornell Aeronautical Laboratory, Inc.

AIRCRAFT DESIGN ENGINEERS have considered many methods of overcoming the inherent shortcomings of lightweight materials. Perhaps one of the most intriguing ideas has been the use of sandwiches.

The combination of various low-strength materials into structural sandwiches is not new, but the expansion of this principle into aircraft use is fairly recent.

The purpose of presenting this paper is to review some of the work carried out at Cornell Aeronautical Laboratory, Inc., on nonmetallic materials and to outline the fabrication techniques used in the production of a structural sandwich wing using the materials developed.

For the last several years, a substantial amount of our research work on plastics has centered on the investigation and development of materials and techniques for the construction of sandwich radomes for high-speed aircraft and missiles. These radomes, of necessity, were nonmetallic in nature with skins of glass-reinforced plastics and cores of balsa or glass-fabric honeycomb.

Because of the compound curvature of the radomes, the balsa or honeycomb core was extremely difficult to shape, and the fabrication processes were time-consuming. These core materials also had a limited resistance to heat.

The early work at Cornell Aeronautical Laboratory therefore involved the development of a new core material under the sponsorship of Wright Air Development Center.

The target objective of the program was the development of materials, formulations, and processes for a foamed-in-place core material having the following principal characteristics.

(1) Low density: Weight, in range 8–10 lbs./cu.ft.

(2) Good mechanical properties: Satisfactory strength at room and at elevated temperatures—i.e., ultimate tensile and compressive strengths of 300 psi, and shear modulus of 10,000 psi at room temperature. At 500°F., 50 per cent of the strength at room temperature after soaking for one-half hour at 500°F.

(3) Good electrical properties: Dielectric constant of 1.25 and loss tangent of 0.004 at frequencies ranging from 60 cycles up to 30,000 mc.

(4) Adhesion: The adhesion at the interface between the core and the glass-reinforced laminate skin with shear strengths in excess of 100 psi.

(5) Uniform structure: The foam cells shall be small, homogeneous, and with no voids over $^1/_8$ in. in diameter. No large cracks shall appear after heating at 500°F. for one-half hour.

(6) Ease of handling: The core material shall be such that it is easily processed, requiring no specially trained personnel. The core material must lend itself to use in sandwich designs involving compound curved shapes. The sandwich skins, between which the core material is to be expanded, will range from approximately 0.010 to 0.060 in. in thickness. The total thickness of the sandwich ranges from $^1/_4$ to $^3/_4$ in.

With no restriction on the use or selection of raw materials, processes, and techniques, it would appear on first analysis that no great difficulty should be experienced in developing a satisfactory heat-resistant, foamed-in-place core material. The paradoxical nature of the program, however, soon becomes apparent when one starts to make such foams. To make a good, uniform core material is one thing; to make good, high-strength, low-density, heat-resistant, foamed-in-place material is definitely another.

The first 6 months of the program were spent in the evaluation of commercially available resins for foams, foaming agents, and methods of foaming. In this preliminary survey it was found that none of the commercial resins or foaming agents gave a core material that even approached the target objective. It was also established that the foaming technique developed by Goodyear Research Laboratory, under a previous WADC contract, offered the best method for obtaining a foamed-in-place core material with the uniformity desired for radome sandwich structures. This foaming process involves the reaction of alkyd resins with isocyanates to give a polyurethane and carbon dioxide. The carbon dioxide, which is a product of the condensation, acts as the foaming agent.

Presented at the Materials and Processes Session, CAI-IAS International Meeting, Ottawa, Canada, Nov. 3–4, 1955.

* Head, Plastics Section, Materials Department.

A number of isocyanates were studied, and, in general, 2,4,m-tolylene diisocyanate gave the most satisfactory results. Using this isocyanate, and also testing with other foaming agents, commercial resins were investigated in an effort to develop a high-temperature, foamed-in-place core material. The commercial resins invariably failed for one or more reasons. The most common defect was the inability to be adapted to any foaming technique, and this resulted in foams of extremely poor quality or, in some instances, in a total collapse of the foamed product.

Many experimental resins were formulated in an effort to devise a good heat-resistant foaming alkyd material. Among the intermediates investigated were phthalic and chlorinated phthalic anhydrides and many other polybasic acids. The polyfunctional alcohols that were studied included glycerol, ethylene, diethylene and propylene glycols, mannitol and pentaerythritol.

For the purpose of screening the resins and foams developed, the foams were tested in compression at temperatures arbitrarily selected as 75°, 300°, 375°, and 400°F. after soaking for one-half hour at those temperatures.

A polyurethane foam approaching the target objective of this program has been prepared from one of the unsaturated alkyd-triallylcyanurate copolymeric resins developed, using tolylene diisocyanate for a foaming agent. Such foams have retained a large percentage of their strength when tested at 400°F., after soaking for one-half hour at those temperatures. The best of these resins, No. 31, has been produced by American Cyanamid Company on a pilot-plant scale. It is being offered for sale as Laminac 4231.

Foams ranging from 3 to 20 lbs. per cu.ft. can be made from Laminac 4231. Fig. 1 shows how the compressive strength at room temperature varies with the density.

Table 1 outlines the typical compressive strength obtained with resin No. 31 at various temperatures.

Fig. 2 shows the flatwise compressive strength, at various temperatures, of a sandwich with 1/32 in. glass-reinforced skins.

Fig. 3 shows the typical flexural strength of a similar sandwich at 75° and 400°F.

Fig. 4 shows the average shear strength of the same sandwich at 75° and 400°F.

A considerable amount of development work had to be carried out in perfecting the foaming technique. Such problems as the proper catalyst and cure and methods of mixing the resin and foaming agent all had to be worked out. The complete foaming process developed is outlined below.

TABLE 1

Compressive Strength (psi) Obtained with Resin No. 31

Density,					% Loss		
lbs./ft.^{3}	75°F.	300°F.	375°F.	400°F.	300°F.	375°F.	400°F.
12.5	295	280	270	220	4.4	7.5	26.2
11.0	205	200	175	150	2.5	15.0	26.5
9.7	162	134	122	110	17.5	24.7	32.0

The results obtained in this program represent an advance in the use of structural, high-strength, heat-resistant core material that can be foamed in place.[1]

As a logical corollary to the work on heat-resistant sandwiches, we have just undertaken a developmental

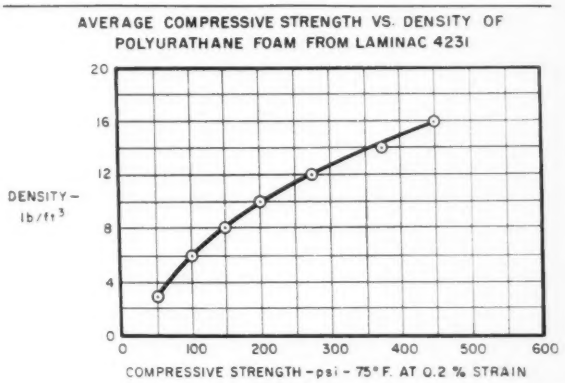


FIG. 1.

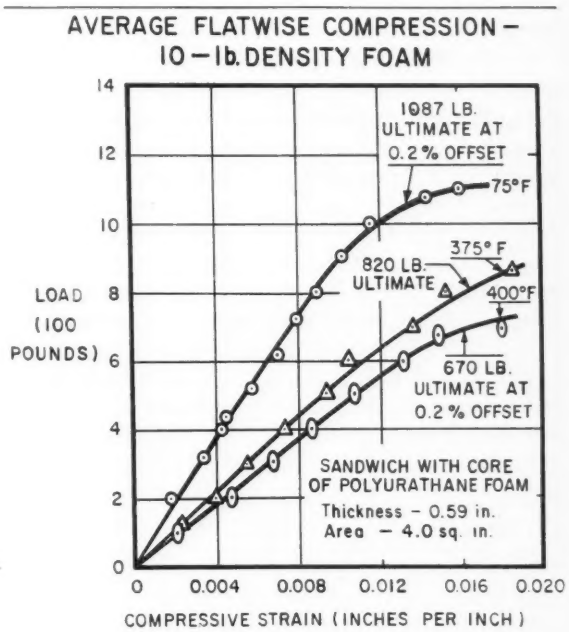


FIG. 2.

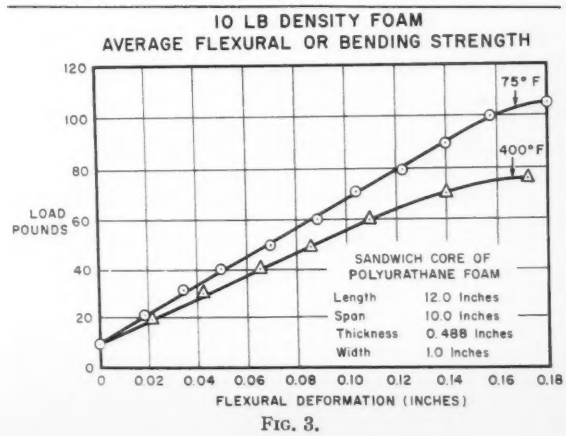


FIG. 3.

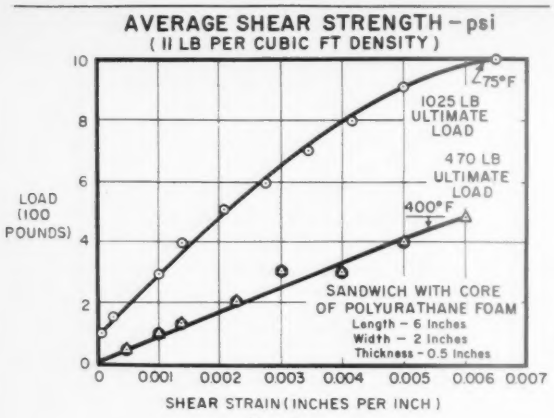

AVERAGE SHEAR STRENGTH – psi
(11 LB PER CUBIC FT DENSITY)
LOAD (100 POUNDS)
SHEAR STRAIN (INCHES PER INCH)
75°F
1025 LB ULTIMATE LOAD
470 LB ULTIMATE LOAD
400°F
SANDWICH WITH CORE OF POLYURATHANE FOAM
Length – 6 Inches
Width – 2 Inches
Thickness – 0.5 Inches

FIG. 4.

study of heat-resistant laminates for WADC under Contract No. AF 33(616)-2515. In this work our objective is to develop improved, heat-resistant polyester-triallylcyanurate copolymer glass-reinforced laminates that will not crack or craze upon postcuring or exposure to 500°F. for extended periods.

Since this program is relatively new, we have obtained only preliminary data. Fig. 5 indicates how the flexural strength and modulus of elasticity are reduced as a glass-reinforced laminate is exposed to elevated temperatures for 1/2, 200, and 1,000 hours.

Another investigation at the Laboratory was aimed at exploring the feasibility of designing and fabricating a lightweight, high-strength, missile wing of sandwich construction. The wing has a glass-reinforced plastic skin and uses the low-density, high-strength core material developed under the project described above. An important part of the program is concerned with the possible savings in costs and production time which such construction will afford. The following are the main phases of the work program:

Investigation of wing design and structure.
Design of wing.
Mold design and construction.
Fabrication of prototype wing.
Fabrication of two wing sections.
Final report, including drawings, fabrication technique, and comparisons with conventional missile wing.

To date, the first four phases of the above program have been completed, and static testing of the second prototype wing is scheduled to get under way shortly.[2]

TIME OF EXPOSURE IN HOURS	EXPOSED AT 300°F FLEX.	TESTED E-10⁶	EXPOSED AT 400°F FLEX.	TESTED E-10⁶	EXPOSED AT 500°F FLEX.	TESTED E-10⁶
0.5	45,000	2.8	42,700	2.7	32,000	2.6
200	46,200	2.7	40,000	2.6	18,000	1.7
1000	40,000	2.8	38,600	2.4	5,000	1.0

FIG. 5. Ultimate flexural strength and modulus of elasticity of glass-reinforced triallylcyanurate laminates after exposure to elevated temperatures.

FOAMING PROCESS

Step 1

A weighed amount of resin is poured into mixer.

Step 2

For every 100 parts of resin by weight, 85 parts by weight of 2,4,m-tolylene diisocyanate are added slowly to the resin. When the tolylene diisocyanate, which has a viscosity in the same range as water, is added all at once to the alkyd resin, it floats on top of the resin, and there are two distinct phases. When the mixer is started, the tolylene diisocyanate splashes out; it is therefore necessary to add this material in about four or five portions at 3- to 4-min. intervals. The mixing of the tolylene diisocyanate and the alkyd resin into a homogeneous blend takes 20 to 25 min. at 75°F.

Step 3

The reaction between the foaming agent and the alkyd resin is extremely exothermic. It is necessary to keep the batch at a temperature of 75° to 85° at all times by the addition of crushed dry ice. If the temperature is allowed to reach 95°F., the reaction will proceed so rapidly that the entire foaming reaction will be completed in a few minutes without any control.

Step 4

After the tolylene diisocyanate has been completely blended into the Laminac 4231 in 25 min., 2 to 3 per cent by weight of di-tert-butyl peroxide catalyst, based upon the resin, is added to the mixture.

Step 5

As the reaction proceeds, the viscosity increases. After 35 min. of total mixing time has elapsed, the viscosity of the mixture is taken at 3- to 5-min. intervals until a viscosity of approximately 1,500 poises at 80° to 85°F. is reached. This viscosity is usually reached after 45 to 55 min. of total mixing time. At this time 8 to 10 per cent by weight (based upon the resin) of Aerosol-Acetone solution is added. (This solution contains 10 per cent of Aerosol OT in 90 per cent of dry acetone.)

Step 6

Mixing of the Aerosol-Acetone into the foam is continued until a reduced viscosity of 300–500 poises is reached. The foam is then poured into the mold. The mold is then closed and the foam cured for 1 hour at 150° to 160°F., 2 hours at 300°F., and 2 hours at 375°F. The mold is then cooled to room temperature.

REFERENCES

[1] Campagne, P. J., Preston, H. M., and Wahl, N. E., *Development of Heat-Resistant Foamed-in-Place Dielectric Core Materials for Sandwich Radomes*, Wright Air Development Center Tech. Report 54-249.

[2] Williams, S., and Bird, W. W., *Material Tests Design and Stress Analysis of a Glass Reinforced Plastic Wing*, Cornell Aeronautical Laboratory Report BE-688-M-2.

Aircraft Accident Investigation

Group Capt. R. C. Davis, RCAF*

A discussion of accidents in relation to some of the precepts for safety design suggested by the Daniel and Florence Guggenheim Aviation Safety Center.

Introduction

In a somewhat different atmosphere, the text of my remarks on accident investigation might be: "We must learn from the mistakes of others. We may not live long enough to make them all ourselves."

The Daniel and Florence Guggenheim Aviation Safety Center has set forth a number of precepts for aircraft design in an excellent booklet entitled *Design for Safety*. My duty involves a constant study of aircraft accidents, both here and abroad, and I should like to explore certain of these precepts in detail. Their importance to the designer cannot be overemphasized.

Precept I

Procedures for adequate maintenance and operating practices established by designers should be consistent with average human effort, ability, and attitude.

The Situation—A pilot rolled his aircraft to the inverted position and, almost immediately, the engine flamed out. Normally 10 to 12 sec. of engine operation could be expected while inverted. The pilot returned the aircraft to the upright position and made a forced landing. Although he escaped injury, the aircraft was destroyed.

Investigation—Investigation revealed that the negative *g* valve in the fuel system had been incorrectly installed following a main fuel tank change.

The Hazard—The *g* valve lever had been designed in such a manner that it could be installed in the reversed position, in which case it was not readily apparent that the valve did not seat properly. In this condition, the engine would be starved of fuel almost immediately after the aircraft was inverted.

The Fix—A fix was not authorized in this case as the aircraft type was being phased out of service. I am sure that there would have been no difficulty in redesigning the lever to prevent its assembly in the reversed position.

Precept II

The aircraft and its components must be protected against the effects of normally inadvertent or uncontrollable human errors or carelessness.

Case 1

The Situation—An aircraft of a particular type was seen to dive suddenly into the ground from level flight. The pilot was killed, and the complete destruction of the aircraft precluded determining the cause from evidence in the wreckage.

Investigation—Investigation was concentrated on the fore and aft control system in the aircraft type. Runaway trim and foreign objects were suspected as cause factors. An investigation of a pilot's report on the same type of aircraft in which sticking fore and aft control was experienced directed attention to the method of fastening an inspection fairing to the fuselage adjacent to the stabilizer power control unit. Seven screws were used, and instructions called for one to be used in a specific hole to be shorter than the other six in order that it would not interfere with the movements of a lever in the fore and aft control system. One of the longer screws was found in the critical hole which explained the pilot's complaint. The use of long screws was believed to have caused the accident previously mentioned.

The Hazard—Replacing an inspection panel or fairing should be a simple matter and not one liable to create a major hazard by causing interference with critical flight controls.

The Fix—The fix in this case was to blank off the hole in the fairing which required the short fastening screw.

Case 2

The Situation—After completing a sharp turn, a dive, and a pull-up at relatively low level, an aircraft suddenly dived into the ground. The pilot was killed, and again complete destruction of the aircraft precluded obtaining evidence that would establish the

Presented at the Aircraft Safety Design and Accidents Session, CAI-IAS International Meeting, Ottawa, Canada, November 3-4, 1955.

* Director of Flight Safety.

cause. Runaway trim and foreign objects were suspect.

Investigation—This particular type of aircraft is fitted with electrically operated trim controls. A junction box contains a number of electrical terminals for the wiring, including that which leads to the trim motors. A loose piece of metal inside it would be sufficient to short two adjacent electric terminals, which in turn would give a full deflection of one set of trim tabs causing a violent maneuver of the aircraft. All that was required to initiate the trouble was that the pilot maneuver the aircraft in a manner which would dislodge a washer or wire clipping from a crevice in the box and cause it to short two electric terminals in the control system. If it occurred at low altitude, the pilot would not have sufficient time to take recovery action.

The Hazard—Where electrics form part of a critical flight control system, the shorting of terminals by foreign objects mislaid or left in the adjacent area may be sufficient to cause a fatal accident and/or the loss of an aircraft. A $^1/_4$-in. length of wire or a washer, the diameter of a pencil, may do the trick.

The Fix—The fix in this case was to insulate the electric terminals in the junction box.

Case 3

The Situation—During a night flight on instruments the passengers in a small transport-type aircraft requested an adjustment of the cabin heat. The pilot adjusted a control. Shortly afterwards an engine seized, and an emergency landing was successfully made.

Investigation—The control pedestal on this type of aircraft contains three controls within 4 in. of each other. The control knobs are approximately the same shape and size. Two of the controls are for cabin heat adjustments, and the third when activated shuts off the supply of oil to one engine.

Investigation revealed that the engine had seized because of oil starvation and that the oil shutoff valve had been activated. The pilot, with his attention concentrated on instrument flying in a darkened cockpit, had inadvertently selected and pulled the oil shutoff valve control instead of that for the cabin heat.

The Hazard—Controls located necessarily in close proximity because of space limitations, having critical and different functions and fitted with similar knobs, expose the pilot to the hazard of inadvertent operation. The risk is particularly high when the pilot's attention is distracted during instrument flight at night with the cockpit lights dimmed.

The Fix—The interim fix in this case was to fit a soft metal strap over the oil shutoff valve control which is used only in the case of an in-flight engine fire. The value of shape coding for aircraft controls to minimize the probability of pilot error in control selection by simplifying discrimination processes is reasonably well known.

Precept III

Design structures and mechanism to function safely and dependably over long periods of repeated use.

The Situation—Immediately after take-off, an aircraft rolled to the right, and, after reaching 90° of bank, altitude was lost and the aircraft struck the ground partially inverted. There is a power boost system using hydraulic pressure to supplement manual pressure on the aileron control system in this type of aircraft. Operation is such that the pilot retains feel of the control yet is able through servoaction to produce a much greater force on the aileron than is applied at the control stick. The power unit consists essentially of an actuating cylinder and a control valve with the necessary linkage. It also incorporates a debooster cartridge which reduces stick sensitivity at low aileron loads. Within the cartridge a spring is held in place by an internal circlip.

Investigation—On investigation it was found that the circlip had come out of the cartridge allowing the spring bungee to extend beyond its normal travel and jam. When this occurs, the servovalve will be so placed as to direct hydraulic pressure to one side of the actuating cylinder, forcing the ailerons to their full travel. The linkage would be thrown out of adjustment, and the pilot would be unable to move the stick to apply opposite aileron.

The Hazard—It could not be definitely determined whether the cartridge was incorrectly assembled or whether the circlip did not withstand repeated use. Nevertheless, it would appear that the use of circlips in such a manner in critical controls is not a good practice.

The Fix—The fix in this case was to redesign the cartridge, replacing the circlip with a cap which screws on.

Precept IV

Parts or components of the aircraft other than basic structure should be designed to fail with safety. This means that failure will not create additional or cumulative hazards.

The Situation—While at a high altitude the pilot of a single-engined aircraft experienced an engine seizure. The pilot set up his forced-landing procedure heading for the nearest suitable airport, which was some distance away. The pilot arrived over the field without further difficulty. During his final approach to the field, control of the aircraft was lost and the aircraft crashed.

This particular type of aircraft is fitted with power controls using hydraulic pressure supplied by an engine-driven pump or, alternately in the case of emergency, by an electrically driven pump. In the case of engine seizure, the battery is the only source of electricity to drive the pump, and control of the aircraft can be maintained only so long as there is life in the battery. The life remaining in the battery depends on many variable

(*Continued on page 47*)

Experiment and Theory in the Investigation of the Behavior of Structures at High Temperatures

An account is given of the problems of creep, thermal stresses, and buckling in consequence of creep or thermal stresses which arise from aerodynamic heating in the structural components of supersonic aircraft.

N. J. Hoff*
Polytechnic Institute of Brooklyn

Introduction

Shooting stars appearing with some regularity in the sky in late summer are proof of the theoretical conclusion that bodies proceeding at high supersonic speeds through the atmosphere are heated by the air stream. As man is now in the process of creating stars by sending missiles through the upper atmosphere and designing satellites which will circle the globe, there is an urgent need to explore in more detail the phenomenon of aerodynamic heating and its effects on the structural parts of airplanes and missiles.

Meteorites show flow lines and pits on the surface; from this it has been concluded that the materials of which they are composed are melted, sublimed, and even burned at the high temperatures to which these bodies are exposed when traveling through the atmosphere. It is also known that smaller meteorites do not reach the surface of the earth but burn up completely in the air.

It is interesting to note that the physical phenomena of melting, subliming, and burning in consequence of high speed have already been reproduced experimentally in shock tubes. These phenomena are being studied by physicists because of their vital importance to the design of missiles.

The Phenomenon of Creep

Perhaps the earliest observation of a structural effect of heating concerns the phenomenon of stress relaxation. Bolts tightened properly when a steam turbine was started were found loose after weeks of operation at high temperatures. The problem was analyzed by Soderberg in 1936.[1] He showed that the relaxation of the initial stress could be calculated from the creep law of the material. Creep is the property of a solid to deform continuously with time under constant loads. It can be observed with all structural metals if the temperature is sufficiently high.

Presented at the Structures Session, CAI-IAS International Meeting, Ottawa, Canada, Nov. 3–4, 1955.

* Head, Department of Aeronautical Engineering and Applied Mechanics.

At the present time, many research and testing laboratories are engaged in carrying out creep tests in tension. The machines used in these investigations are basically simple. A weight is attached to the lower end of a straight tensile test specimen which is maintained at a prescribed elevated temperature.

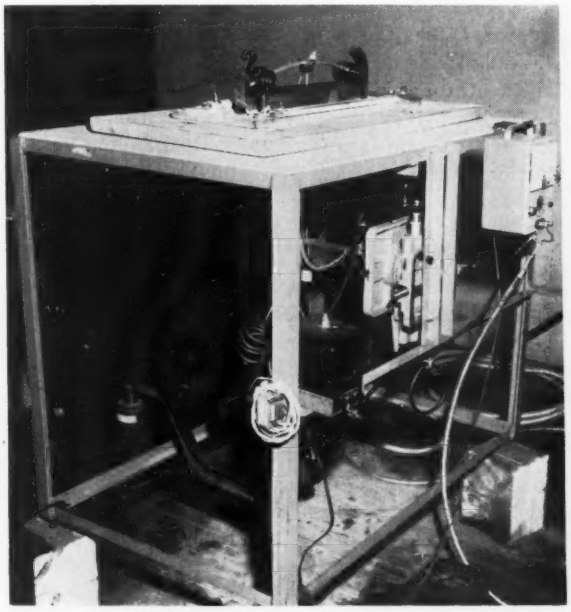


Fig. 1. Flexural creep test setup.

The elongation of the specimen is measured and recorded as a function of time. Creep tests are often run for several weeks, or months, and sometimes even for years.

If the behavior of a metal in tensile creep is known, in principle it is possible to calculate the deformations of a beam made of the same material when it is subjected to bending. In practice, however, this calculation is not simple because the creep laws of metals are highly nonlinear, as will be discussed later. In addition, the material of the wrought alloy bars used for

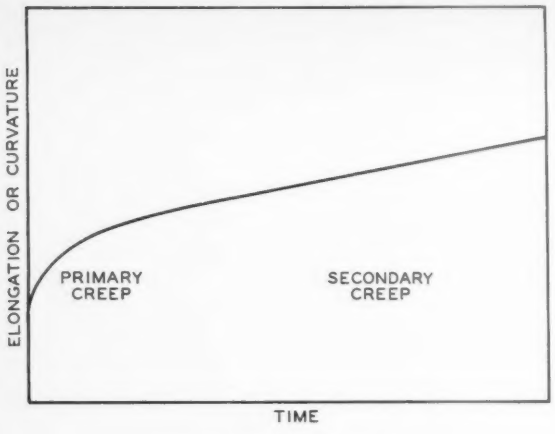


FIG. 2 CREEP CURVE

structural purposes is not homogeneous. Because of the larger amount of cold work to which it had been subjected, the surface of a rod differs from its center both metallographically and in its mechanical properties. The test results recorded represent, therefore, average values of the properties over the cross section. The averaging process is different in a tensile test, when all the fibers of the cross section are subjected to approximately the same stress, from what it is in a bending stress in which the stresses vary rapidly from the neutral axis of the cross section toward the surface of the bar. It is advisable therefore to run creep bending tests if one is interested in determining the behavior of structures whose members are subjected to bending moments.

Fig. 1 is a photograph of the bending test rig now in use at the Polytechnic Institute of Brooklyn. The test specimen shown is a 5052-0 aluminum-alloy bar of rectangular solid cross section. The bar is supported near its ends by means of fittings provided with ball bearings. The ball bearings are so arranged that their axes coincide with the neutral axes of sections of the specimen. To the ends of the bar are attached fittings with machined circular cylindrical surfaces whose axes coincide with those of the ball bearings. Weights are applied to these fittings by means of thin phosphor bronze strips. From the lower ends of the strips is suspended a horizontal beam to the middle of which weights can be attached. One-half of the weight is transmitted by each strip. When the beam specimen deforms, the ends of the specimen are displaced, but the distance between the line of application of the load and the reaction force at the center of the ball bearing remains unchanged. As in the tests, the weight suspended from the horizontal beam varied between 24 and 40 lbs., and the distance between the points of support and the points of load application was 2 in., the constant bending moment acting on the beam between the ball bearings varied from 24 to 40 in.lbs.

To the center of the specimen is attached a chain by means of a yoke. A rod suspended from the chain passes through the armature of a linear differential transformer. As the total weight of the equipment supported by the center of the beam is only 2.35 oz., the effect of this weight on the creep deformations of the beam is negligibly small.

During the test, the deflection of the midpoint of the beam is measured by means of the differential transformer. The armature is fastened to a rigid bar, which in turn is attached to a universal vise. The two screws of the vise are used during the test to maintain the armature of the differential transformer in the same position relative to the core. This is indicated by a null-reading of the potentiometer. The displacement is measured on the scale of the universal vise.

Fig. 1 shows the test equipment with the cover removed. Before the test is begun, the cover is put in place. It encloses a volume of 0.56 cu.ft. On the insulating base plate are arranged four electric resistance strip heaters totaling 2.5 kw. They make it possible to heat up the oven to 600°F. in about an hour. This oven, as well as all the others in the Structures Laboratory of the Polytechnic Institute of Brooklyn, was designed for a maximum temperature of 1,000°F.

A number of tests were carried out with this piece of equipment, and the results obtained were plotted as changes in the curvature of the beam as a function of time. The curves were quite similar to those obtainable from tensile creep tests. They could be represented approximately by the creep law originally proposed by Andrade in 1910[2]:

$$L = L_0(1 + \beta t^{1/3})e^{\kappa t} \tag{1}$$

In this equation L_0 is the original length of the bar, L is the length after a time interval t beyond the load application, and β and κ are constants for the duration of the test. These constants change with the temperature at which the test is carried out and when the applied load is changed.

It is of interest to note that two creep laws widely used today can be derived from the Andrade equation. At the beginning of the creep process t is small. Then Eq. (1) reduces to

$$\epsilon = \beta t^{1/3} = f_1(\sigma, T)t^{1/3} \tag{2}$$

where ϵ is the engineering strain. Eq. (2) is widely accepted as the law governing primary creep. According to Kennedy,[3] the equation characterizes the creep behavior of most metals with satisfactory accuracy during the entire creep phenomenon.

When the time is large, straightforward mathematical manipulations transform Eq. (1) into

$$\dot{\epsilon}_{\text{nat.}} = \kappa = f_2(\sigma, T) \tag{3}$$

In this equation $\epsilon_{\text{nat.}}$ is the natural strain; the dot over the symbol indicates the time derivative. Consequently the left-hand member of Eq. (3) is the time rate of change of the natural strain in the material. According to the equation, this rate is constant in any individual test carried out at constant stress and constant temperature. When the creep strain is less than

3 or 4 per cent, the difference between the natural strain and the engineering strain is negligibly small. Under these conditions it is permissible to rewrite Eq. (3) in the following form

$$\dot{\epsilon} = f(\sigma) \qquad \text{if} \qquad T = \text{const.} \tag{4}$$

There is a great deal of experimental evidence available to show that the functional dependence of the strain rate on the stress can be represented with sufficient accuracy in engineering by means of a power law. This power law can be written as

$$\dot{\epsilon} = (\sigma/\lambda)^n \qquad \text{if} \qquad T = \text{const.} \tag{5}$$

Here σ is the tensile stress applied to the specimen, and λ is a constant. The exponent n is also a constant; naturally both λ and n vary with temperature.

It is usual to determine the value of n in the following manner: A number of tensile creep tests are carried out at the same temperature but at different values of the stress σ. The creep curves are plotted as shown in Fig. 2. The slope of the approximately straight portion of the curve is determined; this is the so-called steady creep rate or minimum creep rate. Next the steady creep rates are plotted against the stress on double logarithmic paper. In many cases the points can be connected by a straight line. It is not difficult to show that the slope of this line is the value of n.

As all creep tests show a great deal of scatter, it is evident that many tests must be carried out before the slope of the straight line, and consequently the value of n, can be established with any degree of confidence. Since some of these creep tests take a long time to perform, the time necessary for the determination of n is considerable. For this reason a testing machine is now being developed at the Polytechnic Institute of Brooklyn which will reduce the number of tests needed to determine the value of n. A sketch of the machine is shown in Fig. 3.

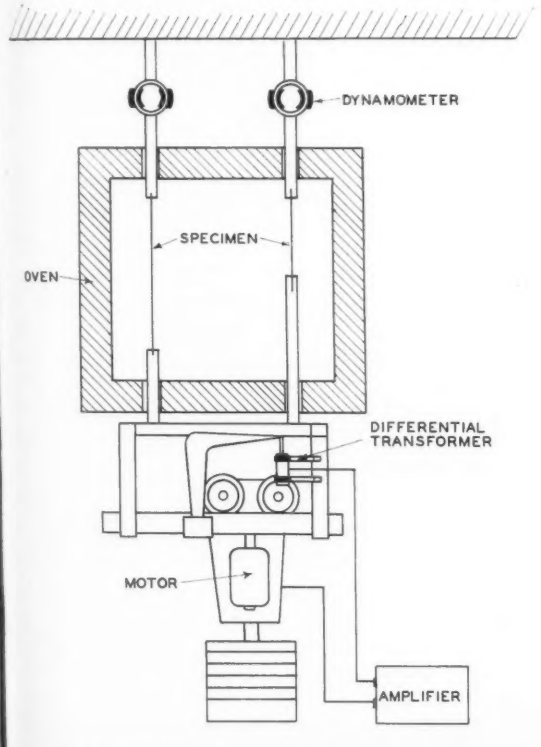


FIG. 3 TENSILE CREEP MACHINE FOR DETERMINING n

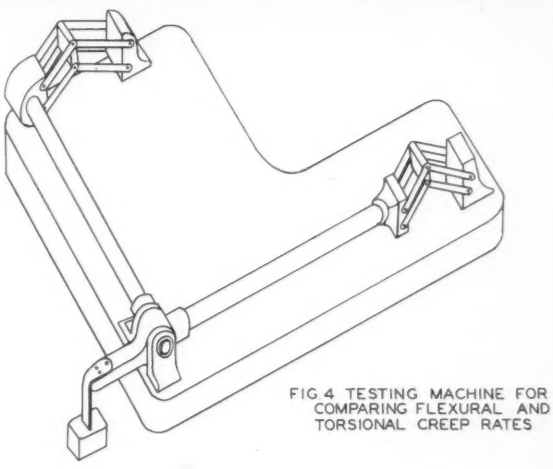


FIG. 4 TESTING MACHINE FOR COMPARING FLEXURAL AND TORSIONAL CREEP RATES

The testing machine consists of an oven in which two test specimens of the same material and same cross-sectional area but of different length are subjected to loads at the same constant temperature. The load is applied by means of a carriage which is provided with a mechanism that keeps the upper surface of the carriage horizontal throughout the test. In this manner the two specimens must elongate equally at all times. The mechanism contains a pendulum level indicator. From the vertical leg of the indicator a weight is suspended which keeps this leg vertical. To the end of the horizontal leg a rod is attached which enters the armature of a differential transformer. As the armature is rigidly attached to the carriage, any tilting of the carriage changes the position of the core relative to the armature. The signal obtained from the differential transformer actuates a servomechanism which starts a small motor, which in turn shifts the weight suspended from the carriage from right to left or vice versa. The motion of the carriage stops only when the rate of elongation of the two specimens becomes equalized. The two stresses at which this takes place can be computed from the readings of the dynamometers to which the upper ends of the specimens are attached.

In another version of the machine, the carriage is replaced by a parallel linkage.

When all the creep deformations are due to secondary creep as defined in Eq. (5), the value of n can be determined without difficulty from a single measurement of the two loads. With a constant creep rate, the elongation ΔL of a specimen can be written as

$$\Delta L = \dot{\epsilon} t L \tag{6}$$

where ΔL is the elongation of a specimen, L the initial length, and $\dot{\epsilon}$ the constant creep rate of the same specimen, while t is the time elapsed from the beginning of the test. The requirement that the elongations of the two specimens should be the same can be written as

$$(\sigma_1/\lambda)^n L_1 = (\sigma_2/\lambda)^n L_2 \tag{7}$$

The value of n can be calculated from this equation

$$n = \log (L_2/L_1) / \log (\sigma_1/\sigma_2) \tag{8}$$

This machine naturally does not yield any useful results if the deformations of the specimens are due mostly to primary creep or if the steady creep is of a type that cannot be defined by Eq. (5). However, with many materials in useful ranges of the temperature and the stress, Eq. (5) is a reasonable representation of the creep deformations. Under these circumstances the machine permits a rapid determination of the important parameter n from a single creep test.

When the stress distribution is sought in a plate, a shell, or a three-dimensional solid, the one-dimensional creep law of Eq. (5) does not suffice for the analysis. Tests other than tensile and bending tests are required to determine how the creep law can be generalized. One quantity of particular interest in this connection is the ratio of the creep rate in tension or bending to the creep rate in shear. Fig. 4 is a schematic sketch of a machine now being developed at the Polytechnic Institute of Brooklyn for this purpose. As shown in the figure, two tubular specimens are tested simultaneously. Both are attached to a loading arm through which a constant moment is transmitted. The far ends of the tubes are provided with fittings which are attached to fixed points by means of parallel linkages. The parallel linkage at the far end of one of the tubes permits vertical and horizontal translations of the end of the tube but does not permit any rotation of the end section corresponding to bending. At the far end of the second tube the parallel linkage does not permit any twisting of the end section of the specimen, but it does permit arbitrary vertical or horizontal displacement. It follows therefore that the first specimen is subjected to a constant bending moment and the second to a constant torque. The parallel linkages are provided with strain gages which indicate the bending moment and the torque. Naturally a suitable cover is provided, and electric resistance heating elements are used to maintain the temperature of the tubes at a prescribed constant level.

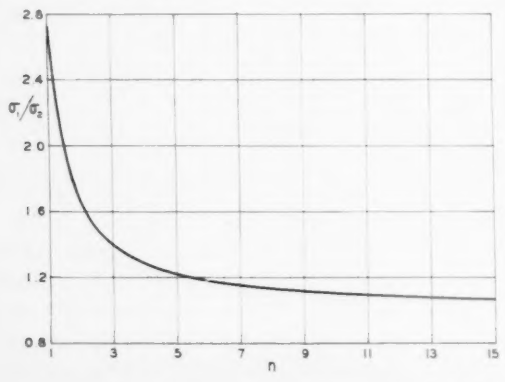


FIG 5 VARIATION OF RATIO OF STRESSES IN TENSILE BARS

The Effect of Creep on the Stress Distribution

It is a mistake to believe that the only importance of creep in structural analysis is the danger of fracture when the load is applied for a sufficiently long time. Another equally important effect is the change in the stress distribution in any statically indeterminate structure. Naturally in a statically determinate structure, creep deformations cannot influence the stress distribution because static determinacy means that the equations of equilibrium alone suffice for the calculation of the stresses. Few structural elements, however, are truly statically determinate. Some ideal pin-jointed frameworks are in this category, but, of course, they do not exist in reality. The rigid connection between the members of the framework at the joints introduces bending moments which can be calculated only if, in addition to the equations of equilibrium, the equations requiring continuous deformations of the structure are also taken into account. Fortunately, with frameworks, the influence of the secondary stresses arising from the rigid connections at the joints is of little importance. For this reason the primary stresses in such rigid-joined framework can be calculated with satisfactory accuracy from the assumption that the structure is statically determinate.

Frameworks are little used nowadays in airplane construction, and there is not much likelihood of their being reintroduced in supersonic airplanes and guided missiles. All the thin-walled or thick-walled structural elements of supersonic airplanes are highly statically indeterminate, and the stress distribution in them is defined only if simultaneously the equations of equilibrium and those governing the deformations are taken into account. But obviously the deformations of a structure whose material is subject to creep differ significantly from the familiar deformations of structural elements for which Hooke's linear law connecting stress with strain is valid. Therefore the structural analyst of supersonic aircraft has to study the effect of creep upon the stress distribution.

The two tensile test specimens in Fig. 3 form a particularly simple statically indeterminate structure. That the distribution of the stresses in them depends upon the stress-strain law follows immediately from the derivations presented in Eqs. (6) to (8). If the material properties are known—that is, if the value of n is given—Eq. (8) can be solved for the ratio of the stresses σ_1 and σ_2. In the particular case that the ratio of the lengths of the specimens is 2.73, solution of Eq. (8) for the ratio of the stresses yields

$$\sigma_1/\sigma_2 = e^{1/n} \tag{9}$$

Numerical values computed from Eq. (9) are plotted in Fig. 5. It can be seen that in the case of linear creep

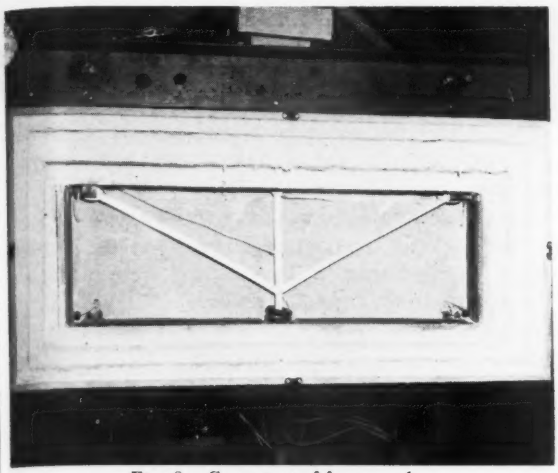


FIG. 6. Creep test of framework.

when $n = 1$, the shorter specimen has to experience a stress 2.73 times larger than the stress in the longer specimen. As the value of n increases, the ratio σ_1/σ_2 decreases. When n is approximately 10, the stress in the shorter specimen is only about 10 per cent larger than that in the longer specimen. These results indicate that the stress distribution in statically indeterminate structures depends very much upon the value of n—that is, on the creep law. One more observation of some interest can be made in connection with Fig. 5; increases in the value of n—that is, a more and more nonlinear behavior of the material—result in smaller and smaller differences in the stresses in the two bars. This result is capable of some generalization. Whenever the material is behaving in an extremely nonlinear fashion, the stress concentrations are always reduced below the level that exists in linearly elastic materials.

The stress analysis of structures subject to nonlinear creep is not simple. However, some results of interest can be obtained when most of the creep deformations are caused by the steady-state creep whose strain rate-stress law is given in Eq. (5). The analysis is considerably simplified by the existence of the elastic analog proved recently.[4] The analog states that the stress distribution in a body whose deformations are entirely described by the creep law of Eq. (5) is the same as that in a body whose material is perfectly, but not necessarily linearly, elastic. Of course, the two bodies must have the same shape, and they must be loaded and supported in the same manner. The stress-strain law of the material of the analogous body must be prescribed as

$$\epsilon = (\sigma/\lambda)^n \tag{10}$$

The analysis is quite simple for statically indeterminate frameworks containing a single redundant element. The theory has been worked out in detail for such structures, and a number of corroborating tests have been carried out at the Polytechnic Institute of Brooklyn. Fig. 6 shows the test equipment used in the framework tests. The framework is placed in a flat oven measuring 10 by 19 by 39 in. The oven is provided with four electric resistance strip heaters totaling 2.5 kw. In addition, two electric resistance ring heaters (150 watts total) are arranged near the attachment of the bar which supports the load and an electric resistance immersion heater (100 watts) at each upper end point of the diagonal members of the truss. The additional heaters are needed to make up for the heat loss at the attachments. The upper end points of the two slanting bars of the framework are attached to adjustable fittings, while the vertical bar is suspended from a dynamometer outside the oven. A dead-weight load is applied to an extension of the framework in the downward direction.

In the tests carried out, the frameworks were manufactured of 0.064 in. thick 1100-O aluminum-alloy sheet. The temperature of the oven was brought up to 600°F. in about 1 $^1/_2$ hours; this time was needed to stabilize a uniform temperature distribution over the framework. The temperature was measured at four points by means of thermocouples. When a satisfactory uniform temperature was reached, the vertical downward load was applied to the specimen, and readings were made with the dynamometer and recorded as functions of time. At the moment of load application, before creep deformations could take place, the stress distribution in the structure corresponded to linear elastic behavior. For the particular conditions prevailing in the test specimen, the central bar carried 80 per cent of the total load. As creep deformations developed, the load carried by the central bar decreased and the load transmitted by the slanting bars increased with time. The changes in load value took place rapidly at the beginning and more and more slowly later. The load readings asymptotically approached a value which could be calculated if the parameter n of the creep law was known. Under the conditions of the test, the value of n was about 12, and, after an extended period of creep deformations, the load carried by the vertical central bar was about 53 per cent of the total applied load. The heating was controlled manu-

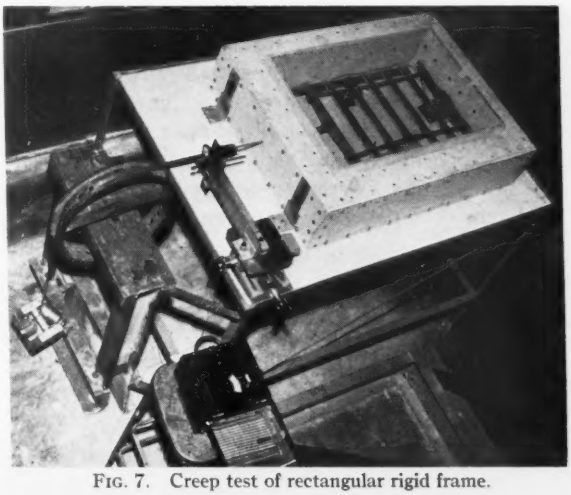


FIG. 7. Creep test of rectangular rigid frame.

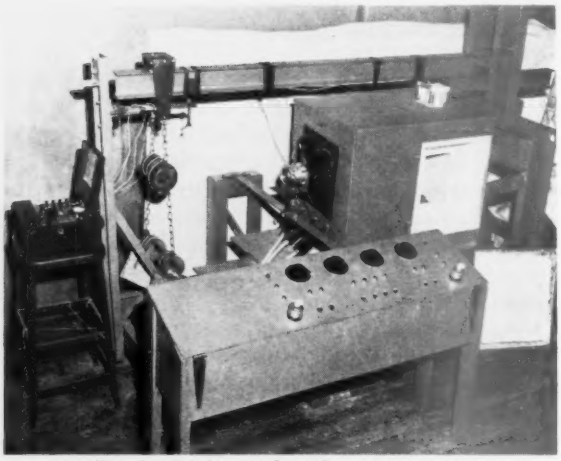


FIG. 8. Equipment for column creep tests.

ally, and the temperature was not entirely uniform in most of the tests. The maximum deviation from the prescribed temperature was ±6°F.

Another structural element in which the stress distribution can be calculated comparatively easily is the rectangular rigid frame shown inside the oven of Fig. 7. The frame is manufactured of $^1/_4$ by $^1/_2$ in. solid rectangular cross section 5052-O aluminum-alloy bar stock. At the corners of the frame, the bars are connected by means of small steel fittings. The mid-point of one of the shorter bars is attached to the wall of the oven, and the mid-point of the other shorter bar carries a fixture from which a rod extends horizontally through the wall of the oven. The end of this bar is attached to a phosphor bronze strip which is fastened to a wheel. The weight suspended from a second phosphor bronze strip attached to the wheel always exerts the same constant pull upon the rectangular frame irrespective of the deformations the frame undergoes.

The oven is built of transite sheets with magnesia block insulation. The cover was removed before the picture was taken. In both the bottom portion and the cover, eight electric resistance strip heaters are arranged; each one of them is rated 500 watts. The banks of strip heaters in the top and in the bottom were automatically controlled by saturable reactor controllers. In addition, manual control was provided for two 250-watt strip heaters at the fixed end of the frame and for one 250-watt strip heater near the point of load application. The uniformity of the temperature was found satisfactory during all the tests. The maximum deviation from the prescribed temperature was ±3°F.

This oven was built after some experience had been gained with the oven used for the framework specimens. The horizontal arrangement of the new oven makes the load application a little less convenient, but it has the advantage that no vertical openings have to be provided. It has been found that vertical openings always cause more trouble than horizontal ones in maintaining a uniform temperature.

The temperature in the rigid frame was measured at six points by means of thermocouples. As the displacements were quite large, they could be satisfactorily measured by means of an Ames dial gage attached to a bar. This bar could be moved around parallel to the plane of the flat top of the test stand by means of a universal vise. The rates of deformation of the frame were also calculated from theory with numerical values of the material constants determined in the bending tests described earlier. Satisfactory agreement was obtained between tests and theory.

CREEP BUCKLING

Another interesting phenomenon introduced into structural engineering is the buckling of compressed elements in consequence of creep. It is well known that no column can be manufactured perfectly straight and no experimental man can ever center a column perfectly in a testing machine. Thus there are always small deviations between the line of action of the compressive load and the line connecting the centroids of the sections of the column. These deviations act as lever arms which, when multiplied by the compressive load, represent bending moments to which the sections of the column are subjected. As bending moments always result in changes of curvature when the material of the column is subject to creep, the initial deviations of the centerline of the column from straightness increase with time. The increasing deviations naturally give rise to increasing bending moments, and the vicious circle ends only when the column snaps through and collapses.

The interesting conclusion to be drawn from this argument is that a column will buckle under any compressive load, however small, if its material is subject to creep. Of course the creep rate of the aluminum alloys used in aeronautical engineering is so small at room temperature that creep buckling may take several million years. On the other hand, at a temperature of 400 or 500°F., buckling may take place in a few hours, or even in a few minutes, under loads considerably smaller than the critical load of the column at the particular temperature. This type of behavior has been investigated theoretically in some detail, and a reasonably large number of tests have also been performed in various research laboratories. The experiments have borne out the essential results of the theory.

Fig. 8 shows the buckling rig used in column testing at the Polytechnic Institute of Brooklyn. The oven is essentially a $^7/_8$ in. thick transite box, with magnesia block insulation and having an internal volume of approximately 3 cu.ft. Inside the oven are 10 electric resistance ring heaters totaling 4.8 kw. In addition, a 100-watt heater is provided at the upper end of the column and a 300-watt heater at the lower end of the column to make up for losses of heat by conduction through the steel structural elements. The fan visible in the picture was installed during the development

phases of the oven, was found unnecessary, and was not used in the main tests.

The console in the foreground houses simple and 3-way switches, as well as four manually operated powerstats (autotransformers) which permit a continuous variation of the heat input. During the final tests, the temperature of the column was measured at three points, and the test temperature of 600°F. was maintained with a maximum deviation of ±3°F. The temperature measurements were made with the aid of iron-constantan thermocouples and a potentiometer.

The loading device is essentially a lever with a mechanical advantage of 5 which transmits a downward load to the top of the column in the oven. About 25 2024-S aluminum-alloy columns have been tested in this oven. It has been observed that the lifetime of the columns decreases slowly when specimens with increasing initial curvature are tested; it decreases more rapidly when the load is increased. A complete quantitative comparison of theory and experiment has not been possible because sufficient information on the creep properties of the material has not been available.

The newest oven in the Airplane Structures Laboratory of the Polytechnic Institute of Brooklyn (Fig. 9) has an internal volume of 54 cu.ft. and a total external volume of 473 cu.ft. It is heated by 120 strip heaters of a total maximum rating of 30 kw. These are controlled by three saturable reactor controllers which provide a continuous variation of the heat input. In addition, manually operated 1,000-watt ring heaters are installed in the end fittings of the specimens, in the strongback, and in two external supports in order to compensate for the heat loss through conduction in the steel structure. With these devices the temperature has been maintained all over the specimen for 4 to 5 hours at the prescribed level of 500°F. with a maximum variation of ±1°F.

Twelve circular cylindrical shells of 16 in. diameter, 48 in. length, and 0.064 in. wall thickness have been tested in this oven. The material of the specimens was 5052-O aluminum alloy. One end of the cylinder was attached to the strongback, while to the other end a bending moment was applied by means of a parallel linkage. In the figure, three sections of the oven are rolled forward on the rails in order to allow the investigator to inspect the rear attachment of the cylinder. The upper and lower bars protruding from the front end of the oven are members of the parallel linkage. They are attached to an upright which is free to move in the fore-and-aft direction. To the same upright are attached two slanting bars from whose intersection point to the left, outside the picture, the dead-weight load is suspended. The middle bar, attached to the upright by a ball bearing, carries a counterweight to compensate for the weight of the end fixture of the specimen.

All the cylinders tested failed by buckling in consequence of creep. No theory has yet been developed to predict the lifetime of such cylinders.

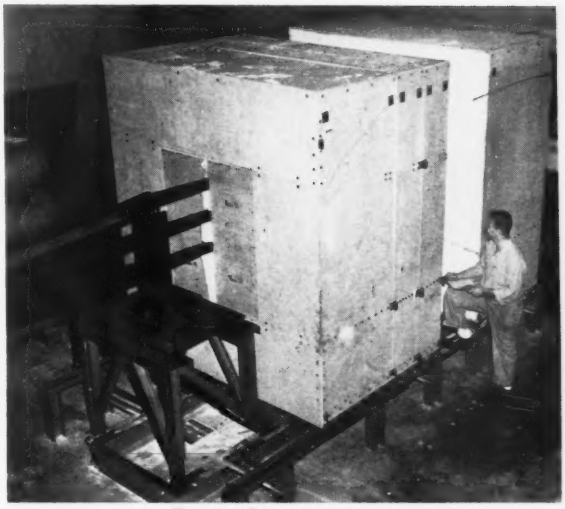


FIG. 9. Large creep oven.

THERMAL STRESSES

When a missile proceeds through air at a high supersonic speed, its surface is heated extremely rapidly while its interior remains comparatively cool, at least at the beginning of the flight path. The hot exterior tends to expand, but its expansion is restrained by the colder interior. The expanding exterior exerts a tension on the interior while the resistance of the interior creates compression in the exterior. In this manner stresses arise in the structure which are known as thermal stresses.

When the stresses are large in a hot metal structure, considerable creep deformations can develop. High thermal stresses in comparatively cool elements occasionally cause cracking. Therefore a theoretical analysis and an experimental determination of the thermal stresses are of considerable importance to aircraft structural analysts.

The ovens described earlier are not well suited to the investigation of thermal stresses because they are slow in heating up. Better results can be obtained by electromagnetic induction heating. The design and construction of an induction heating unit began at the Polytechnic Institute of Brooklyn in 1950. Fig. 10 shows the completed unit heating a small model of a box beam. The machine operates at 20 mc., and it has a maximum power consumption of about 2.5 kva. and a power output of about 1.2 kw.

A more recent unit is shown in Fig. 11. It is a modification of a commercial machine used originally for metallurgical purposes. The unit has a power rating (output) of 20 kw. and operates at about 400 kc. In the photograph the machine heats a model of a diamond-shaped supersonic wing.

In principle, an electromagnetic induction heater creates a high-frequency electromagnetic field inside the coil. Because of this field, currents of equal frequency are induced in the test specimen inside the coil. These currents are restricted to a layer of small thickness in the material. It is known that the depth of

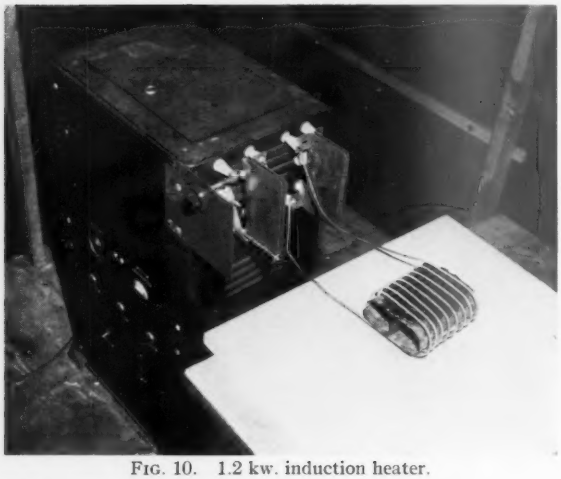


FIG. 10. 1.2 kw. induction heater.

penetration is inversely proportional to the square root of the frequency. In tests with steel specimens heated by the 20-kw. unit, the depth of penetration was about 0.002 in. The current induced in the surface of the specimen heats the surface.

Uniform surface temperatures can be obtained only when the coils surround the specimen without major gaps. The spacing in Figs. 10 and 11 is far too wide for good results. The coils were wound so loosely only to permit a better view of the specimens in the photographs. Similarly, for efficient heating, the coils should be placed close to the contour of the specimen. In some of the tests efficiencies of 80 per cent have been reached at the Polytechnic Institute of Brooklyn. By this is meant that the heat input per second in the specimen was 80 per cent of the power output of the machine. The power output of the machine was about 50 per cent of the input.

The efficiency of heating is only about half as much if aluminum-alloy specimens are heated by the same machine. However, the efficiency can be raised if the aluminum-alloy specimens are sprayed with iron.

One of the advantages of induction heating is that it is concentrated on the surface just as aerodynamic heating transfers heat to the surface of objects immersed in the airflow. In Fig. 10 the flanges of the box beam are heated while the central web remains cool. The steel specimen shown has a length of 6 in., a width of 5 in., a height of 2 in., and a wall thickness of 0.024 in. After 60 sec. of heating, the middle of the web reached a temperature of 327°F., while at the middle of flange the temperature was 440°F.

Much more rapid heating was, of course, possible with the 20-kw. unit. With a steel specimen of 1 in. diameter and 2 in. length, a maximum heat input of 400 B.t.u. per sq.ft. per sec. was attained. The surface of the specimen became red hot in less than 1 sec.

A new induction heater of 200-kw. output is now being provided for the Aircraft Structures Laboratory of the Polytechnic Institute of Brooklyn. The increase in power by a factor of 10 permits the maintenance of the heating rates already realized, even though the surface of the new models is 10 times and their linear dimensions are 3.16 times the corresponding values in the earlier specimens.

THERMAL BUCKLING

The greatest objection to thermal stresses is that they cause buckling in all the thin or slender elements of the structure. Buckling in turn leads to loss of strength and rigidity; if it takes place on the surface of a structure exposed to the air stream, it can also modify the flow pattern in such a manner that the lift of the body decreases and its drag increases considerably. In the course of this process, control surfaces may become ineffective and wings and tail surfaces may flutter and disintegrate.[5]

That the danger of buckling is not remote can be ascertained easily by calculation. If a steel plate of 8 in. width and 0.064 in. thickness is heated uniformly to 100°F. above its initial temperature, each inch of its length expands 7.5×10^{-4} in. because the coefficient of linear expansion of steel is 7.5×10^{-6} per °F. If the elastic modulus is taken as 28×10^6 psi, a compressive stress of 21,000 psi is needed to shorten the plate to its initial length. This means that such a stress must actually develop in the plate if the expansion is completely prevented by unheated structural elements to which the plate is attached. But the buckling stress of a long, simply supported plate of the dimensions given can be calculated as

$$\sigma_{cr.} = 3.61\, E(t/b)^2 = 3.61 \times 28 \times 10^6\, (0.064/8)^2 = 6{,}460 \text{ psi}$$

Consequently, under the conditions stated, a temperature difference of $(6{,}460/21{,}000)100 = 31$°F. suffices to cause buckling.

Of course, perfectly rigid restraint is never available in an actual structure. But the thermal stresses arising from nonuniform heating are large enough in reality to cause buckling. This was observed in many tests carried out with box beams of the type shown in Fig. 10. After the test the plates were always permanently

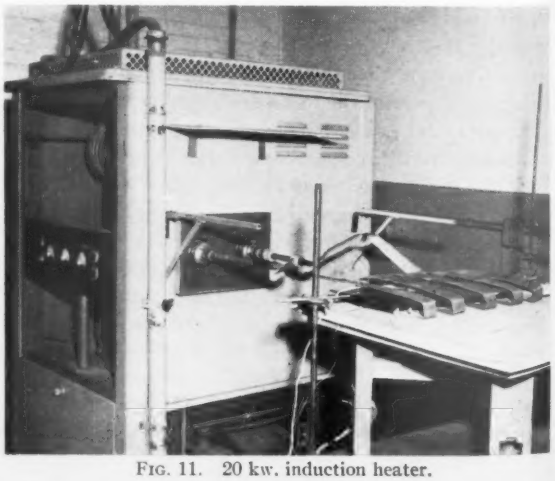


FIG. 11. 20 kw. induction heater.

buckled to such an extent that the box beam was obviously no longer usable as a structural element.

In a few tests performed with solid diamond-shaped wings of steel, such as the one shown in Fig. 11, the leading and trailing edges became much hotter than the middle of the wing. Consequently large compressive stresses developed in the front and rear portions of the wing, and the edges became wavy.

Acknowledgment

Most of the theoretical and experimental research discussed in this paper was carried out at the Polytechnic Institute of Brooklyn under the sponsorship of the Air Force Office of Scientific Research, the National Advisory Committee for Aeronautics, the Office of Naval Research, and the Wright Air Development Center. The author greatly appreciates the opportunities for research provided by these agencies of the United States Government. He is also grateful to Professor Burton Erickson, Dr. Sharad A. Patel, and S. Lederman of the staff of the Department of Aeronautical Engineering and Applied Mechanics for information received from them and incorporated in this paper.

A list of 61 articles dealing with the subject matter of this paper was recently published by the author.[6]

References

[1] Soderberg, C. Richard, *The Interpretation of Creep Tests for Machine Design*, Trans. ASME, Vol. 58, p. 733, 1936.

[2] Andrade, E. N. da C., *On the Viscous Flow of Metals and Allied Phenomena*, Proc. Royal Soc., London, Ser. A, Vol. 84, No. A567, p. 1, June, 1910.

[3] Kennedy, A. J., *On the Generality of the Cubic Creep Function*, J. Mech. & Phys. Solids, Vol. 1, No. 3, p. 172, April, 1953.

[4] Hoff, N. J., *Approximate Analysis of Structures in the Presence of Moderately Large Creep Deformations*, Quart. Appl. Math., Vol. 12, No. 1, p. 49, April, 1954.

[5] Dryden, Hugh L., and Duberg, John E., *Aeroelastic Effects of Aerodynamic Heating*, Presented to the Fifth General Assembly of AGARD (NATO), in Ottawa, Canada, June, 1955.

[6] Hoff, N. J., *High Temperature Effects in Aircraft Structures*, Appl. Mech. Rev., Vol. 8, No. 11, p. 453, November, 1955.

Aircraft Accident Investigation

(*Continued from page 38*)

factors, and hence we have a situation in which an engine seizure may culminate in the pilot being unable to actuate the flying control surfaces.

Investigation—As the battery was destroyed in the crash, investigators were unable to prove that the battery had lost its charge prior to impact. Nevertheless, there was some evidence to suggest that this was the case.

The Hazard—The hazard in this design is that an engine seizure may culminate in the pilot being unable to control the flight of the aircraft.

The Fix—Emergency flight-control systems must be made independent of electrical or hydraulic power sources.

Conclusion

In conclusion I would request that my observations be not taken as being critical of the aeronautical engineers who designed our magnificent aircraft. They are without doubt amazingly skillful, resourceful, and competent men. Despite their foresight, their past experience with older types of aircraft, and extensive prototype testing of a new type, it must be expected that some design weaknesses may become evident only after the aircraft has been in use for some time. *It is paramount in the interest of safety that, once errors have been revealed and a fix established, they should never be permitted to appear again in a later design of any type of aircraft.* It may be appropriate to suggest here that many share in the responsibility for safe design. They include those who set the operational requirement, prepare the design specifications, and monitor the mock-up and prototype trials. As the performance of our aircraft increases, so do the penalties we pay for unsafe features. All of us who are concerned must give our utmost attention to the demands for safety. Learning from the mistakes of others is the least that can be done.

Air Safety...

A Report on the Sixth Annual Air Safety Seminar, held in Taxco, Mexico, November 17–20, 1955.

by Otto E. Kirchner*

THE SIXTH ANNUAL Air Safety Seminar conducted by the Flight Safety Foundation took on a Pan-American atmosphere by being held at Taxco, Mexico. This beautiful city of homes, built along lines of Spanish architecture during the reign of the Spanish explorers who exploited the silver mines, lies 100 miles southwest of Mexico City.

Interest, adherents, advocates, and momentum still continue to rise for Jerry Lederer's crusade for increased flight safety, as attested to by the attendance of 137 participants from 60 different organizations plus 16 commands of the military forces.

The success of these seminars is due, in part, to the informality and confidential "hair down" nature of the discussions and to the limited size of the participating groups.

Although much of the material presented at the 3-day sessions was off the record, the following highlights give a fair idea of the subjects covered and the importance of the discussions involved.

TURBULENCE

Jerry Lederer introduced the subject of turbulence by quoting statistics. Of 102 passengers killed in scheduled operations in 1953–1954, turbulence accounted for 73 per cent in four accidents.

Henry Harrison, Jr., of United Air Lines, Inc., opened the sessions with a discussion of the problems of introducing air-borne radar in United's air-transport fleet. The use of radar equipment will apply to their Convairs first because of the greater percentage of instrument weather experienced.

Mr. Harrison also described the indoctrination programs being given the pilots in the theory, operation, and maintenance of air-borne radar.

He also stressed that United's first use of this equipment was for by-passing turbulent thunderstorm areas. It is not to be used for terrain clearance.

* Formerly with American Airlines, Inc., now with Boeing Airplane Company.

VORTEX WAKES

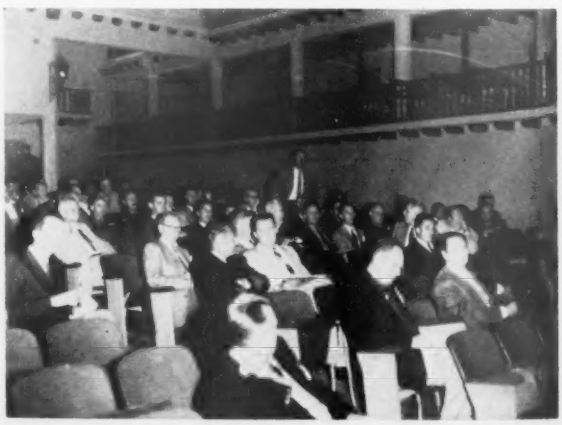
Paul E. Allen, of Beech Aircraft Corporation, voiced some concern about flying in the presence of wing-tip vortex wakes. He felt that some accidents could not be otherwise explained, unless we recognize that wakes from large passing aircraft might be a principal contributory factor. He said that expert opinions vary from "it can happen" to "it can't happen."

This phenomenon has also been noted by the NACA and is reported by them in NACA Technical Note No. 3377. Experience to date indicates that the exhaust blast from jet airplanes dissipates quickly at about 300 ft. with minor air disturbances to following aircraft; but the vortex wake turbulence may persist for several minutes in a very powerful form.

SAC EXPERIENCE WITH JETS

Major T. P. Savage, of Strategic Air Command, discussed the crew transition period from reciprocating-powered aircraft to the larger jet type. He explained that training programs were geared to the particular

Technical sessions are held in the theater of the Posada de la Mision, at Taxco.



background training and experiences of the pilot. In one sense, the jet was just another airplane but required more exacting performance from the crew. Military experience with jets has proved them to be more reliable, operationally. Forty-six hours of simulated training are required prior to 40 hours of in-flight training on jets.

Major Savage said the military have accumulated considerable experience by which the air-transport companies could benefit. He also quoted comparative hours for servicing and maintenance of the two types. In this respect, the jet was placed in a very favorable light because of the difference in work capacity between the two types. He presented detailed data to support his conclusions.

Pilot Stress in Accidents

Captain S. J. Wisler, USN, talked about "Man and His Behavior." For 50 years a considerable amount of information has been collected about aircraft accidents, but not much analysis of the pilots who were involved has been made—i.e., what pertinent and significant reactions of the pilot may be due to pressures of society, his environment, etc. Pathological aspects, as well as psychological, should be investigated. One question which may be asked is, "Will a standard of tests ever be available which will indicate how a pilot's mind reacts under the pressure of an actual emergency?"

Captain Wisler was joined by many from the floor in a discussion of the proper approach to cockpit standardization. Just how the responsibility should be divided between the creator of the aircraft, the builder, the buyer, and the user can be a much debated subject.

Crash Location Beacon

Brigadier Gen. Thomas DuBose, of the Air Rescue Service, MATS, carried the audience along on a typical search and rescue operation through the medium of a sound film. Many thousands of hours are spent in search efforts each year. The first 24 hours are the most critical. General DuBose said that a crash or ditching scene electronic marker would reduce considerable search time and result in a higher "rescue" percentage.

Air Rescue Service is working on such a device, and he gave details of a development now in process. The principle of operation of the system involves electronic ground station triangulation. It is automatically ejected and transmits on a 1,000-cycle tone modulation, as well as 8,364 kc. and 242 mc.

D. P. Huckabee, of Tone Generators, reviewed the status of his development of a crash or ditching scene electronic locater for air-transport operation. The search for a lost air-line airplane only 10 miles east of the Berlin, N.H., airport, in 1954, started him on this development. He has produced a lightweight unit, low in cost and with minimum maintenance, using long-life silver cell batteries. Both tone and audio transmission are provided over a range of approximately 150 miles. The weight is being held to 6½ lbs.

Air Defense Command Intercepts

Colonel John F. Sharp reiterated that the mission of the Air Defense Command was to "defend the United States against air attack." He went into great detail to explain the reasons for which "intercepts" were ordered against air-transport aircraft. If an aircraft is classified as "unknown," it must be intercepted if it is within an ADIZ or headed toward an ADIZ. No "practice" intercept on commercial air lines is ever allowed, and violations are severely reprimanded.

Colonel Sharp also outlined methods and procedures by which the task of the ADC could be simplified by specific actions of the commercial air-line operators.

Crash-Resistant Fuel Tanks

A progress report on the status of crash-resistant fuel tanks was presented by R. J. Schroers of the Technical Development and Evaluation Center of the CAA. He

Jerry Lederer accepts a silver key to the city from Taxco's Mayor, Senor Manual Castrejon Gomez, at a special meeting of the City Council.

The Annual FSF Award Dinner is held at noon (in accordance with Mexican custom) and is served on the Terrace Dining Room of the Hotel de la Borda.

said that a new concept has been developed with reference to the design loads of crash-resistant tanks. Tank locations should have a large bearing of the design load requirements imposed. A crash-resistant tank in the outboard wing section need only be a little stronger than the adjacent wing structure. Design of crash-resistant tanks in the fuselage areas near the location of passengers should take a little more load than the design requirement of passenger seats.

Although considerable research has been carried out on the crash-resistant tank material, the problem of connections, fittings, and accessories is yet to be solved, although the outlook is good.

Mr. Schroers also reviewed an industry conference on anticollision lights recently held in Indianapolis. He said that with increasing speeds of aircraft the human eye could not be depended on to serve as a scanner for avoidance of oncoming aircraft. The Technical Development and Evaluation Center had started a development to provide more conspicuousness by the use of lights, luminous paint, and solar reflectors. The conference also concluded that the approach and terminal area warning problem was entirely different from the en route operation.

Traffic Density

Present traffic problems in aviation, particularly those pertaining to airports, seem rather insignificant when reviewed in the light of what they will be in the future. Jerry Lederer presented a movie film taken of the Mitchel Field radar scope of New York area air traffic which was shown at 160 times normal speed. This provides an insight into the future. The traffic blips literally resemble a bee hive. Even at 16 times, the problems will be aplenty—and this not in the too distant future.

Collision Lights

H. W. Atkins, a pilot for Northwest Airlines, Inc., has developed a collision warning device made up of high-intensity stroboscopic, capacity-discharge type, flashing white lights. He has analyzed and determined relative flight danger zones to be three of importance. The one involving approaching airplanes within 60 deg. of dead ahead is the "collision impending" zone. For this area, Mr. Atkins' light flashes at a rate of 3 cycles per sec.—fast enough for the crews to be impressed with the need of taking positive action for divergence.

Collision courses which range from 60 to 120 deg. each side of the centerline are called the "danger" area. Here, the rate of flash is 1 cycle per sec. In this sector a few more seconds may be allowed to take evasive action. An airplane being overtaken would show a flash through a zone 60 deg. each side of the centerline. This is known as the "information" zone, where the light flashes only once in 3 sec.

Mr. Atkins claims this light can be seen in the daytime and more so at dusk when the collision hazard is the greatest.

Tacan

Both John Brophy, of the Federal Telephone & Radio Co., and Capt. Sam Saint, Consultant for the Air Navigation Development Board but representing his own thoughts, reviewed the growth of air-transport navigational aids. When landing requirements were 4 to 5 operations per hour, single 4-lobe beacons were quite suitable. With the approach of 100 to 120 operations per hour, more advanced equipment will be required. Captain Saint expressed some concern for a system which tries to process aircraft arrival hours ahead. It is his conviction that the "hopper" or "funnel" will still be necessary. All incoming aircraft are steered into the mouth of the funnel and singly controlled out of the small end into the proper airport or runways, of which there will be several serving one "funnel."

John Brophy explained how the Tacan system would enable a pilot to fly closer parallel courses than any other system. This would allow movement of greater numbers of aircraft between specific terminals. Tacan is the only system which will permit parallel courses spaced to a minimum of 4 miles, he said. Mr. Brophy pointed out that one of the technical advantages of Tacan was its low site susceptibility. Some of the other advantages were availability for both small and large aircraft. The 9-lobe pattern gives Tacan its inherent accuracy.

Mexican Navaids

Maurice J. Mitchell described RAMSA, Radio Aeronautica Mexicana, S.A., as a private company commissioned by the Civil Aeronautics Department of Mexico to provide air traffic control, aeronautical weather information, and radio aids to navigation within the Republic. This company is made up by representation membership of the principal aviation enterprises. These facilities are offered to the private, executive, and nonscheduled operators on a subscription basis. Mr. Mitchell said that while RAMSA operates the services at Mexico City, a private operator, like American Airlines, operates the facilities at Monterrey—for which they receive credit in the overall accounting of distribution of costs. He also described Mexico City as being one of the few cities with two control towers.

Mr. Mitchell also mentioned that all towers have bilingual operators. Mexico is making considerable headway in the nature of airways and regulations concerning instrument flight. He also said that Mexico is taking a leading part in the training of controllers through the International Civil Aviation Training Center in Mexico City. Its purpose is to provide training to students from throughout Latin America in all fields of civil aviation. The extent of operations in or out of Mexico City averages 200 per day, of which 170 are scheduled air lines.

Visual Aids for Airport Indoctrination

C. H. LeRoy gave the reasons of American Airlines for selecting synchronized sound, slide strip films over 16-mm. movies for use as a principal aid in training pilots on airport approaches and let-downs. He illustrated their use of this film by showing its adaptation to a LaGuardia Field ILS approach from the outer-marker into the pull-up and go-around. Desirable features of strip film are the ease with which it may be stopped at any place for extended discussion and the low cost of a revision to the film. Their trial runs with LaGuardia have convinced American Airlines to go ahead with all of their other stations.

Airports

Herbert O. Fisher, of the Port of New York Authority, discussed the airport operator's problems in keeping his airport efficient. He gave at present 120 operations per peak ILS hour between the Port of New York Authority controlled airports—Idlewild, LaGuardia, Newark, and Teterboro. He said acceptance rates must be improved with improved facilities and discussed landing aids, runways, taxiways, terminal facilities, and control procedures. The responsibility of the airport operation involves provision for and constructions to mount facilities of the CAA, which operates the towers.

Mr. Fisher also mentioned the need to require a minimum amount of air-borne navigational equipment for aircraft that operate into congested areas like New York and also the restriction of some of the other types of aircraft, such as gliders, from the area. He said an airport operator must be alive to future developments, such as high-speed taxiways, new types of taxi lights, flush runway lights, increasing helicopter traffic, and overshoot safety barriers.

Survival in the Tropics

Dr. Paul Nesbitt, of the U.S. Air Force, discussed survival in the tropics. Considerable air-transport and military operations pass over the South American jungle. Therefore, advantage should be taken of the knowledge which has been developed over the years in jungle survival. The record to date has been good. Dr. Nesbitt said that, in a forced landing, preference should be given to ditching in lakes or in streams over landing in the jungle. The jungle quickly envelops even large objects like aircraft. For the military, parachute escape is preferred. The major problem is lack of survival "know-how." The dangers are snakes, drinking water, and sunburns. In general, Dr. Nesbitt said, the natives will be found to be amiable—with some exceptions. He impressed the need for a basic amount of survival equipment and training, and particularly good health. A study of 1,000 jungle crashes disclosed that a pickup averaged within 3 days.

Decompression, Bird Strikes, and High-Speed Evacuation

Lieutenant Col. John P. Stapp, USAF, described the incidence of bird strikes on aircraft windshields. The highest strike on record was at 19,000 ft. with a Condor. He said that, as far as it is known, there have been no crew fatalities to date from this cause. Colonel Stapp also included in his comments the record of hail damage to windshields. The maximum size hail experienced has been 5 ½ in. in diameter and weighed 1½ lbs. He said the CAA, TDEC, Indianapolis, is redesigning their windshield test gun to throw a 4-lb. object at 600 m.p.h.

Colonel Stapp also reported on survival at simulated ejection speeds approaching 935 m.p.h. One of his objectives, he stated, is to determine that area of high-speed operation where survival is still possible under forced ejection using present methods. For this purpose, improvements are being made to the high-speed acceleration track at Holloman Air Force Base.

Crash Rescue

The research of W. L. Alford, of the NACA Langley Field Laboratory, on emergency rescue external markings was reported on by Melvin Gough. By means of slides, he showed the difference between present practices and the revised markings. Considerable improvement is indicated in the proposed methods.

Mr. Gough also mentioned the NACA method of keeping the local fire and rescue groups supplied with an up-to-date loose-leaf book of their great variety of operating airplanes. Through this, fireman can get a quick grasp of aircraft exit locations en route to the crash or while alerted to one.

Dr. Barry King, one of the recipients of the 1955 Flight Safety Foundation Awards, described his recent simulated ditching tests, which were held in the Chesapeake Bay, near Norfolk, Va., in cooperation with the Coast Guard. Various methods of evacuation were tried out. Recommendations as to the most desirable method must await the completion of the films' time study analysis. One factor disclosed in the review of Dr. King's ditching films was the raft inflation delay which slowed evacuation procedures.

Al H. Hobelmann and John Hammill, of Walter Kidde & Company, Inc., demonstrated what could be accomplished by adapting an aspirator to the present life raft inflation mechanism. A 10-man life raft, which was so equipped, was demonstrated to inflate in 4 sec. Some further development is necessary before the modification can be considered satisfactory for operational use.

John F. Avellar described and demonstrated the new Air Cruiser inflatable pneumatic escape slide. This slide was developed to overcome the fabric slide's main deficiencies, such as needed ground assistance. As a by-product for off-shore ditching, the chute can serve as an extremely efficient life raft for support of immersed persons pending help from shore. This

facility was tried out for the first time as a substitute bouyant life raft in Barry King's tests. The inflatable slide accomplishes the extra features of shorter preparation time, no ground assistance, and flotation at small expense of weight and stored size of container.

Evacuation is more than just equipment and procedures. Ira Thatcher, of United Air Lines, discussed a method of using films for the training of crews to make the most of equipment which is on the airplane. He said that United encourages its employees who use its lines to go through the evacuation training. These employees are then issued a card which properly identifies them to the crew if on board during an actual emergency.

Aircraft Manufacturers Safety Groups

There has been an increase in the formation of safety engineering groups in the ranks of the aircraft manufacturers. Some of these groups have been in operation for sufficient time for them to have been shaken down to definite responsibilities. Two specific organizations were discussed—the Northrop organization, by G. M. Russel, and the organization of Chance Vought, as told by C. O. Miller. (Mr. Russel's paper appears on page 54 of this issue.)

It is interesting to note the number of responsibilities in which the two groups are similar. It is quite evident that the safety groups aim to be a service organization. The safety group supplies the design group with information that the designers do not have time to accumulate. To mention a few, it investigates, catalogs, points out harmful trends, trouble areas, etc. Although the exact details of how this is done may vary with each company, the objective seems to be the same. Both Mr. Russel and Mr. Miller mentioned the inclusion of reliability studies as part of their responsibilities. Reliability analysis is becoming more and more an important consideration in aircraft design procedures, but its place in an engineering organization is still debatable in some companies.

Safety Cooperation

The noncompetitive aspect of flight safety between aircraft manufacturers was pointed out by John B. Pitkin, of Lockheed Aircraft. He said that on all safety problems affecting the turbocompound installation in either the Douglas or the Lockheed aircraft, the engineering groups of both companies worked as if they were all responsible to the same party.

Backward Facing Seats

A. B. Sorin, of the U.S. Navy, described catapult tests carried out on both the forward facing and rearward facing aircraft cabin seats. The rearward facing seats included a 20-deg. load vector either side of dead ahead. He found that, for the conditions tested, the instrumented dummies were subject to less destructive loads when facing aft.

The writer wishes to say that there has been a considerable amount of tests of this order by various laboratories. It would be desirable to get all of this information together to determine what needs further testing. The writer feels that there are additional situations—such as greater angles from dead ahead and also the reclining passenger—to take into account.

Mr. Sorin also described in great detail the equipment used in these tests. Seat ash trays, for example, separated from seats at relatively low *g* forces in some cases.

Crash Survival Lessons

An important part of the Flight Safety Seminar each year is a report by Howard Hasbrook on the lessons we learned during the past year with reference to survival. Mr. Hasbrook reviewed the many ways in which passengers receive injuries. He felt the need for stronger tie-downs for seats, buffet equipment, and fire extinguishers. He also mentioned the need for delethalization of seat backs, hat racks, window frames, wall structure sharp edges, reading light switches and air outlets. Mr. Hasbrook breaks the airplane into four general areas of destruction: (a) cockpit, (b) cabin—forward, (c) cabin—center, and (d) cabin—rear. His accident investigation experiences make him a strong proponent of the shoulder harness to increase crew survival.

Boyd Myers, III, of NACA, discussed the crash tests of instrumented light airplanes simulating a dive in consequence of a stall. High-speed movies enabled observers to follow the action of the destructive forces throughout the crash sequence. Mr. Myers mentioned that detailed information on these tests is reported in NACA Technical Note No. 2991.

Cabin Attendants' Problems

The honor of being the first woman to present a paper at a Flight Safety Seminar goes, I believe, to Miss Carole Haverfield, who represented the Air Line Stewards and Stewardesses Association. Miss Haverfield said that members of ALSSA were employed by 26 different air lines. She felt that there was a certain amount of underestimating of the matureness of cabin attendants by companies. For this reason they refrain from extending to them the degree of responsibility which they are capable of performing in the cabin. Miss Haverfield said that the cabin attendant must be the leader in an emergency. The attendant is usually most familiar with the location and operation of emergency equipment.

She also reviewed many cabin details which could bear further study for better safety. She felt that much could be done to improve the safety and comfort of stewardess' seats and illustrated deficiencies with effective slides. In addition to many other safety suggestions, she said that, to expedite emergency instructions to the attendant, a phone at his or her seat would be desirable.

Dr. Barry King (*center in left photo*) and Francis L. Moseley (*center in right photo*) receive the 1955 Flight Safety Foundation Awards from Mayor Gomez, while FSF Director, Jerry Lederer, beams approval.

Distinguished Latin American Guests

The importance placed on the meetings and discussions by Latin American officials was attested by an official visit from the Governor of the State of Guerrero. Other official representatives at the Award Dinner were Gen. Alberto Salinas Carranza, Director of Civil Aviation for Mexico; Captain Montoya, Director of Civil Aviation in Nicaragua; the Mayor of Taxco, Senor Manual Castrejon Gomez; Gen. Juan Azcarate; and Senor Norberto Guillen, Director of Civil Aviation in Honduras. Honored guests also included Senora de Salinas and Senora de Castrejon.

Awards

The Annual Award Dinner was held at the de la Borda Hotel at 2:00 p.m., on November 19, with General Salinas as the guest speaker.

At the end of his speech, General Salinas presented the Flight Safety Foundation Awards for 1955, presented on behalf of *Aviation Week* magazine. Recipients were Dr. Barry A. King "for organizing, conducting, and evaluating research in the problems of survival and escape from aircraft involved in accidents."

The second award went to Francis L. Moseley "for initiative and extraordinary ingenuity . . . developed overnight the first automatic direction finder." (The third award was presented to Stanislaw Krzyczkowski during the IATA Tenth Anniversary Meeting in New York, October, 1955.)

William Stieglitz, speaking for the attending representatives, presented Mr. and Mrs. Jerome Lederer and Miss Gloria Heath with silver gifts of appreciation for the devotion and unstinted time given by them to the objectives of flight safety.

Now Available

Proceedings of the Second National Turbine-Powered Air Transportation Meeting

Seattle, Wash.—August 8–10, 1955

Contains papers presented at this meeting, complete with figures and illustrations.

Member Price, $3.50 **Nonmember Price, $6.00**

Copies may be obtained by writing to: **Publications Department, Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y.**

George M. Russel*
Northrop Aircraft, Inc.

Air Safety Engineering

A description of the Northrop Air Safety Engineering organization and how it works, and a little of the philosophy of air safety engineering.

THE REGARD FOR human life is a distinguishing basic precept of the democratic philosophy of living. No man should ever knowingly be the cause of harm or death of another person. For this reason, freedom-loving people abhor war and any needless sacrifice of human resources. It is in the highest tradition of the engineer and craftsman that the fruits of his labor provide the public with the safety and protection which it has every right to expect. The much quoted *Canons of Ethics for Professional Engineers* recite:

"He (the engineer) will have due regard for the safety of life and the health of the public and employees who may be affected by the work for which he is responsible."

This worthy ethical attitude, together with strong financial consideration and professional self-interest, should convince the engineer and craftsman that safety is of sufficient importance to arouse and maintain his concern.

Aside from humanitarian considerations, the consequences of aircraft accidents can be catastrophic. In civil aviation, accident costs are measured in millions of dollars of material loss and personal claim, plus other millions in intangible traffic slumps due to adverse publicity. Accidents involving military aircraft are even more serious for several extremely practical reasons:

(1) The state of the country's military preparedness depends upon the number of aircraft and trained crews in being at any given time. Crashed airplanes and dead crews can never carry the battle to the enemy.

(2) Modern warfare is a battle of resources and manpower. Aircraft and crews lost in accidents are a serious drain on both and may easily decide the balance of power.

(3) Our aircraft accident losses are a boon to an enemy. They cost him neither effort nor risk.

(4) Military aircraft accidents represent substantial financial losses which are sapping an already overburdened economy.

(5) Accident losses can never be recouped. They represent untold additional effort to regain an equivalent standing.

Professional self-interest requires that the employee protect the good name of his employer and the reputation of his product by building into the product the highest order of quality and dependability. The degree to which this is accomplished, the relative freedom from trouble and accidents, will determine to a large extent the tenure of the business and of the individual job.

Man's conquest of the third dimension has added greatly to the knowledge required of engineers and craftsmen—in fact, it has added many entirely new crafts and a new phase to the engineering profession. As this science has developed, the airplane has become, in a few decades, a highly complicated mechanism operating in a new realm under conditions of speed, power, stress, acceleration, altitude, climate, and environment which were undreamed of 20 years ago. It is inevitable that mistakes should occur and that accidents should continue to mar a brilliant record of accomplishment. No human effort has ever escaped such a penalty entirely.

Despite aviation's relatively brief span, a well-defined pattern of experience is available to guide the safety-conscious aircraftsman. While it will never be possible to stop all aircraft accidents, it definitely is possible to reduce them materially by utilization of this pool of experience and knowledge relating to accident causes. No individual engineer or mechanic can rely entirely upon his own training, experience, or opinions for the elimination of dangerous conditions, but, by pooling all sources of information for mutual benefit, it is possible to make the sum total of past experience available in a safety program. It is the purpose of the Northrop Air Safety Organization to bring to the attention of all concerned this pool of experience through timely suggestions and reviews of the findings of accident investigation.

The immediate goal of aviation design safety engineers as a group is to derive a series of principles and basic ideas, based on experience, which can be applied to all design features and which will encourage systematic thought with regard to safety and reliability. Even this will not stop all accidents, for no expert nor group of experts, however wise or qualified, is omniscient enough to foresee all possibilities of trouble or malfunctioning that may develop in a new design or the rearrangement of an old one. Safety is everybody's business; its price is eternal vigilance and infinite attention to detail.

Presented at the Flight Safety Foundation Air Safety Seminar, Taxco, Mexico, Nov. 17–20, 1955.

* Supervisor, Air Safety Engineering.

So much for the philosophy of the air safety engineer. I shall next give you a description of our organization at Northrop and explain the way in which it works.

At Northrop Edgar Schmued, Vice-President—Engineering, directed that a separate group be established, reporting directly to the Chief of Associated Projects, which will have the sole responsibility for Air Safety Engineering. It has been my pleasure to have the opportunity to develop this organization, establish its policies and methods of operation, and watch it grow into what I feel is one of the most effective groups of its kind. It has purposely been kept small in number but rich in its background of knowledge and experience. The extremely wide range of knowledge necessary to carry on this work could not possibly be concentrated in any one man. We must have a background of accident investigation, pilot experience, engineering design education and experience, and actual field service experience, and a knowledge of psychology and physiology. Three other men and myself combined possess a working amount of the above-described knowledge and experience, with the exception of physiology. To obtain the latter we have retained as a consultant one of the foremost aviation physiologists available, Dr. Charles Lombard. The fifth man in the group is an ex-Air Force Master Sergeant. His job is to receive, catalog, and place in a readily available form all the varied information received daily from a multitude of sources. These sources include trouble reports from our own technical representatives and from the Air Force; publications and technical data from the Air Force Inspector General's Office, Norton Air Force Base, U.S. Naval Aviation Safety Activity, The Guggenheim Flight Safety Foundation, the Civil Aeronautics Association, Civil Aeronautics Board, National Advisory Committee on Aeronautics, various individuals of an informal air safety engineering group, and the Aero Medical Association; and, finally, through research of all available publications on this subject. From this imposing list you can see we are well supplied with information with which to carry on our work.

Acting strictly as a consultant group, we divide this work into two categories:

(1) We establish problem areas on the aircraft and request the responsible design groups to clear up the problems. We have no actual directive authority to demand changes; however, with direct backing from engineering management we receive the maximum of cooperation to accomplish the best redesign possible that the necessary compromise will allow.

(2) We follow new designs from their inception clear through to the aircraft production stage. In doing this we make every effort, based on research and past experience with existing production aircraft, to eliminate possible safety hazards. Another item in this category is the assisting of the various designers, at their request, in solving service and safety problems in designs presently being accomplished.

In the line of physiology we attempt to keep all toxic materials from entering the cockpit. Requirements for operation at all altitudes are studied, as well as the proper protection of the pilot for any mission he might be called on to perform.

During the rapid development of present-day aircraft there has been one link in the operation of the aircraft that has defied all efforts for improvement. This is the link between the seat bucket and the control stick. As a result of this, it has been necessary to develop a new art in psychology. We have had to study the pilot, watch his actions and reactions, and find some way to bring the airplane back to the pilot so that he can perform the multitude of duties required with less thought on his part. This is better known today as human engineering.

The important thing to remember about air safety engineers, as they are in this group, is that they are provided with the facilities to concentrate on safety in design. This differs from the role of the designer who is burdened with difficult tasks of fitting complicated mechanisms or equipment into predetermined spaces, always with such things as weight limitations being imposed. Because of the extreme complexities of these tasks the designer cannot always detect design errors, such as control mechanisms which can be installed in reverse order or—a common error even more difficult to detect—mechanisms which have bolts that can jam if installed in reverse order. We know such items may go undetected for as much as several years in service before causing disastrous accidents. By being able to concentrate on safety in design, the air safety engineer is able to research extremely small malfunctions which might occur during the design and manufacturing processes. It was recently said that about the only monotonous thing in the aviation business is the constant advancement which is taking place, and it can be readily seen that the newness of the art, combined with economic requirements, necessitate constant scrutiny for practicability.

Every company which has production airplanes in operation can soon develop a history of service and accident information. An alert organization will take advantage of this and use this information to increase the service life of these airplanes and, even more important, put this experience into new designs to make them a safe and serviceable product.

Accident investigation is one of the most important functions of the group. This job is accomplished by on-the-scene investigation of major and significant accidents. A complete and thorough study must be made to determine the causes and results, and the series of events occurring just prior to the accident must be determined and cataloged. Every possible bit of information must be noted even though it appears to have no connection with the particular accident. The compilation of all these seemingly insignificant details can develop a pattern over a series of accidents. This information is carefully listed on a keysort-type card which, when properly used, will establish just these above-mentioned patterns.

Mr. Schmued has established an experimental Flight Safety Board at Northrop. Chairman of this board is the Chief of Associated Projects. The other members are two experimental pilots and myself. The object of the board is to eliminate any safety hazard which might appear on our experimental flight-test airplanes. If these pilots encounter anything that appears to them to be a safety item, they can present it to the board. If the board agrees that this is a safety item, it is cleared up immediately with no questions asked. This board can demand and get action from any person or group in the entire Northrop organization. A sum of money and block of engineering hours have been set aside to accomplish this work. It is the pleasant duty of Air Safety Engineering to see that this work is accomplished without unnecessary delays.

Additional duties of considerable interest have recently been given this group. We are putting our knowledge and experience with manned aircraft to work on our pilotless aircraft program. A complete and thorough analysis of each functional system on the aircraft is made to detect and avoid in-flight failures. We look at each individual component of a system from the standpoint of failure, then, drawing from our past experience with like parts, we list all known failures and determine the effect of the component on the operation as a whole. This information is given to the individual design groups who then make every practical effort to arrange their design to handle these failures should they occur during flight. In addition to this, we attend the launching of the aircraft where we carefully analyze all methods and procedures for safety hazards of any kind. This includes manual handling, as well as automatic procedures and remote controls. We have found an amazing similarity between the launching and flying procedures of the pilotless aircraft and the handling of manned aircraft.

Special IAS Publications

	Member Price	Nonmember Price
Aeronautical Engineering Index – 1953	$ 3.00	$ 5.00*
1952	2.50	4.00*
1951, 1950, 1949, 1948, 1947 (each)	2.00	3.00*
Proceedings of the Second Turbine-Powered Air Transportation Meeting (1955)	3.50	6.00*
Proceedings of the First Turbine-Powered Air Transportation Meeting (1954)	3.50	6.00*
1955 National Telemetering Conference Record	3.50	3.50*
1953 and 1954 National Telemetering Conference Record (each)	2.00	2.00*
Second International Aeronautical Conference Proceedings	15.00	17.50*
First and Second Convertible Aircraft Congress Proceedings (each)	3.00	5.00*
Eighteenth Wright Brothers Lecture—Fatigue Life of Airplane Structures, Bo Lundberg (Reprinted from the June, 1955, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
Seventeenth Wright Brothers Lecture—The First Half-Century of Flight in America, Glenn L. Martin (Reprinted from the February, 1954, JOURNAL OF THE AERONAUTICAL SCIENCES)	0.50	1.00
Sixteenth Wright Brothers Lecture—Technical Trends in Air Transport, William Littlewood (Reprinted from the April, 1953, JOURNAL OF THE AERONAUTICAL SCIENCES)	1.00	1.50
Index to Books on Selected Technical Subjects in the IAS Library (up to 1950), unbound	2.00	2.00*
"Fifty Years of Flight"—A Chronicle of the Aviation Industry in America, 1903–1953, Welman A. Shrader (Published by Eaton Manufacturing Company. Reprinting and Distribution Rights Granted to IAS)	4.50	5.00

*Add $1.00 for orders outside the U.S.A.

These may be obtained by writing to:

Publications Department, Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.

Heart for a new Helicopter

...an achievement in precision and performance

The skill and craftsmanship of
FOOTE BROS. in the manufacture
of gears, actuators and assemblies
has contributed to this achievement

Main rotor transmission for Sikorsky S-58 Helicopter

This trademark stands for the finest industrial gearing made!

FOOTE BROS. Gear-Rated LIFETIME GEARING

FOOTE BROS.

Better Power Transmission Through Better Gears

IAS News

(*Continued from page 25*)

Harold Hertenstein (M), of McDonnell Aircraft Corporation, has been assigned to training activities aimed at developing and stimulating young engineers. With McDonnell since August, he formerly was Director of the Aircraft Maintenance Engineering Department at Parks College of Aeronautical Technology, St. Louis University.

Samuel K. Hoffman (AF), who headed the former Propulsion Center of North American Aviation, Inc., has been named General Manager of the company's new Rocketdyne Division.

Frederick B. Lee (M) has resigned as Administrator of the Civil Aeronautics Administration. He was succeeded by Charles J. Lowen, Jr., Deputy Administrator, who thus becomes an Honorary Member of the IAS.

Robert M. Meisel (TM) has joined Vitro Corporation of America as a Mathematician in the Vitro Laboratories at West Orange, N.J. He was formerly with Republic Aviation Corporation as a Mathematician in the Engineering and Computing Group.

Henry T. Nagamatsu (M), formerly senior Research Fellow and Director of the Hypersonic Wind Tunnel at Guggenheim Aeronautical Laboratory, California Institute of Technology, is now connected with the Research Laboratory of General Electric Company, Schenectady, N.Y.

Milton Rogers (M) has resigned as Engineering Assistant to the Vice-President of Aircraft Armaments, Inc., to join the Air Force Office of Scientific Research as a Research Physicist in the Mechanics Division, ARDC, Baltimore.

G. Rex Shields (M) has been named Manager of Aviation Sales by Axelson Manufacturing Company, Division of U.S. Industries, Inc. He was formerly Assistant Manager of Military Sales for the Allison Division of General Motors Corporation.

Sanford Solarz (TM) has been appointed Advertising Manager of The Liquidometer Corporation. He was formerly Supervisor of Technical Data.

W. A. Reichel, AFIAS, has been elected to the newly created post of Senior Vice-President in Charge of Engineering, General Precision Equipment Corporation. He is Executive Vice-President of a subsidiary, Kearfott Company, Inc.

H. Guyford Stever (AF), Chief Scientist of the U.S. Air Force, has been appointed Associate Dean of the School of Engineering at Massachusetts Institute of Technology. Dr. Stever, who is on leave from M.I.T. until June, also was promoted from Associate Professor to Professor of Aeronautical Engineering.

Adolf K. Thiel (M) has joined The Ramo-Wooldridge Corporation, Los Angeles, as a member of the Senior Staff. He was formerly Chief of the Technical Feasibility Studies Office, Ordnance Missile Laboratory, Redstone Arsenal, Huntsville, Ala.

Frederick A. Winzer, Jr. (M) has been appointed General Sales Manager of The Weatherhead Company's Aviation Division in Antwerp, Ohio. He was formerly Assistant General Sales Manager of the Propeller Division of Curtiss-Wright Corporation.

Abe M. Zarem (M) has resigned as Assistant Director of Stanford Research Institute to go into business as an industrial consultant on research programs and planning. He has opened an office at 727 West Seventh St., Los Angeles.

CORPORATE MEMBER NEWS

• **Aeroquip Corporation** announces a new flexible hose with a detachable, reusable fitting and a tetrafluoroethylene inner tube. The 666 Teflon hose, the company claims, can withstand temperatures from −100° to 500°F. and is impervious to acids and many other fluids that cannot be transported by rubber hoses. It is expected to find wide use in aircraft, airplane engines, and guided missiles.

• **Allison Division, General Motors Corporation . . .** A new Engineering Building with expanded research and development facilities for aircraft engines is under construction at Allison Plant No. 8 in Maywood, Ind. The three-story building, to be completed next December, will have 270,000 sq.ft. of floor space and will accommodate a working force of 2,600 persons. Some of the facilities, scheduled for completion in April, will permit testing of individual combustor components for turbojet and turboprop engines. Facilities for testing compressor and turbine components will be ready in December. Among Allison officials who participated in the ground-breaking ceremony were Ronald M. Hazen, FIAS, Technical Assistant to the General Manager, and Dimitrius Gerdan, AFIAS, Director of Engineering. A 186,000-sq.ft. addition to the Model Shop is also under construction. Both buildings are part of a $75,000,000 Research and Development Center scheduled for completion by 1959 on a 95-acre site. . . . Allison prop-jet engines and Aeroproducts propellers have been selected by Eastern Air Lines, Inc., to power its new fleet of 40 Lockheed Electra air liners. In a joint announcement, the companies said Eastern's order for 200 engines of an improved Allison 501 model, and a similar number of propeller assemblies, will amount to $26,000,000

• **Aluminum Company of America . . .** Aluminum blades 34 ft. long, matched in sets of three, are used in the tandem rotors of Piasecki Helicopter Corporation's YH-16A turbine-driven helicopter. The blades are strengthened internally with a honeycomb of corrugated aluminum foil. Each blade is composed of two plates bonded together with resin adhesives.

• **Avien, Inc. . . .** A liquid-level switch that can be used with any fuel gage to provide level control for tank switching, balancing, etc., is announced by Avien. The switch can be positioned at any selected level on the tank probe to provide high- or low-level signals. Its operation is electrically and functionally independent of fuel gaging equipment. Absence of moving parts improves its reliability. The switch is not affected by vibration, slosh, acceleration, or aircraft attitude and operates over a temperature range from −65° to 200°F.

• **Bell Aircraft Corporation . . .** A detailed, full-scale mock-up of the Bell XH-40, winner of the Army's utility helicopter design competition, has been constructed at the Forth Worth plant. The single-rotor, turbine-powered craft is expected to have a vertical-climb rate of 1,900 ft. per min., a hovering ceiling of 15,000 ft., and a range of 200 nautical miles. The closed cabin carries two pilots and four passengers. Comparing the XH-40 with similar reciprocating-engine helicopters in use today, Bell engineers say its empty weight will be reduced 35 per cent, pay load increased 100 per cent, and cruising speed increased 43 per cent. Designed for front-line operation, the XH-40 is expected to run 1,000 hours between major overhauls. It will be equipped for all-weather flying. It will have metal rotor blades and will be the first helicopter to have in-flight blade tracking.

• **Bendix Aviation Corporation . . .** A large addition to the Pacific Division's Engineering Building has been completed in North Hollywood, Calif. Floor space was increased from 23,000 to 100,000 sq.ft. The area devoted to engineering, development, and test work in the new air-conditioned building equals 50 per cent of the space devoted to manufacturing.

• **Boeing Airplane Company . . .** The basic problems of jet engine thrust-reversing and sound-suppressing have been overcome, and the company is working toward development of such devices to be used on the Boeing 707 jet transport that have been ordered by commercial air lines. Boeing engineers, the

FORECAST: SECURITY—Northrop's dramatic development of long-range, all-weather interceptor aircraft is an important factor in our country's program for protection in the air. As a pioneer in this and other fields, Northrop has initiated many achievements that contribute to national safety. These accomplishments include the Northrop Scorpion F-89 interceptors now stationed at the U.S. Air Force's most strategic bases, ready to rise and destroy hostile aircraft under "impossible" weather conditions. Also included are Radioplane Company's versatile drones and missiles, and Northrop's unmanned Snark SM-62 intercontinental A-bomb carriers. New weapon systems of tomorrow are now being developed by Northrop engineers and scientists. Economical output and prompt delivery are assured by Northrop's balanced production force which capably matches the company's years-ahead vision and planning.

NORTHROP

NORTHROP AIRCRAFT, INC. • HAWTHORNE, CALIFORNIA

Pioneers in All Weather and Pilotless Flight

5-A-52

company announced, are now developing a combination thrust-reverser and sound-suppressor that can be installed as a unit on the tailpipe of the 707's Pratt & Whitney jet engines. A full-scale test, utilizing an experimental fixed thrust-reverser installation on one engine, was carried out successfully with the Boeing 707 prototype last June. The sound-suppressor under development by Boeing regulates the mixing of exhaust gases and surrounding air so that less noise is produced. The nozzle is designed to concentrate the noise reduction in certain frequencies where the reduction is most desirable. The sound-suppressor causes no appreciable reduction in the total available engine thrust. . . . On December 7, the Wichita Division rolled out its first B-52D Stratofortress. The eight-jet intercontinental bomber has been coming off assembly lines at the Seattle plant since March, 1954. The Wichita plant has turned out more than 1,200 B-47 Stratojet medium bombers.

• **Canadair Limited** marked the opening of its new engineering laboratories and guided-missile facility in Montreal with an inspection tour by 75 Canadian government officials and military officers on December 1. The visitors saw 32 different demonstrations and tests in seven laboratories, including a demonstration of the control system of the Velvet Glove guided missile. One exhibit was a full-scale model of the CL-28, Canadair's version of the Bristol Britannia, now in production for the RCAF. This will be the largest plane ever built in Canada. A booklet is available on the new facilities.

• **Convair, A Division of General Dynamics Corporation . . .** In cooperation with the Air Force, Convair's Mechanical Test Laboratories are conducting pilot-ejection tests with a supersonic rocket sled on the ARDC's high-speed track at Edwards AFB. The sled contains an actual nose section and cockpit of the F-102A supersonic interceptor, equipped with its standard pilot-escape system. Over and over, the seat is ejected at high speed with a 6-ft., 200-lb. anthropomorphic dummy instrumented to measure speeds and forces imposed. High-speed sequence cameras and numerous motion-picture cameras beside the track and in the cab record every movement of the canopy, seat, and dummy during and after ejection. Information on the velocities and pressures to which the pilot and his gear are subjected during every fractional second of the escape procedure is gained from complex instrumentation installed in the cab, on the seat, and on the dummy. One important aim of the tests is to eliminate any possible interference by cabin furnishings as the pilot and seat are shot from the cockpit. In addition to determining the upper speed limit for safe pilot ejection in relation to every component of the escape system, the Convair engineers want to determine the trajectory of a canopy jettisoned during a simulated low-speed emergency landing approach. At the same time, new helmets are being developed and harnesses are being perfected. It has been found that a pilot can bail out of the F-102A in just 2 sec. Test data from the timers, accelerometers, electronic pressure pick-ups, position recorders, and microphones are telemetered to receivers situated beside the track. . . . Convair and General Dynamics' Canadian subsidiary, Canadair Limited, are collaborating with the Bristol Aeroplane Company, Ltd., of England, on a joint specification for a new long-range transport airplane. The combined engineering group, working in San Diego, expects the proposed plane to be in the 500-m.p.h. class and to be economical for nonstop transatlantic service. It will be designed around four Bristol BE-25 turboprop engines. The companies plan to produce the aircraft and engines concurrently on both sides of the Atlantic.

Experimental thrust reverser, installed on tailpipe of No. 2 jet engine of Boeing 707 transport prototype, has been tested at taxi speeds up to 98 m.p.h. Yarn tufts trace flow of exhaust gases when filmed.

In high-speed tests of the pilot escape system of the Convair F-102A interceptor, the cockpit canopy is jettisoned, dummy pilot and seat are ejected and then separated automatically, and the dummy parachutes to earth. The F-102A rocket sled, which can pass Mach 1 with 16 rocket motors, is shown being prepared for a test run on the 10,000-ft. track at the Air Force Flight Test Center, Edwards AFB. Forces noted by gages in the cockpit and on the dummy and seat are transmitted by radio telemeter to recording instruments at trackside. The rear fin houses the antenna.

• **Cornell Aeronautical Laboratory, Inc.,** marked its tenth anniversary in December with the dedication of two new buildings completed at a cost of $1,250,000. More than 98,000 sq.ft. of floor space was added to the Laboratory, which now has 1,200 employees. Principal speaker at the dedication was Clifford C. Furnas, FIAS, Chancellor of the University of Buffalo, who has since been named Assistant Secretary of Defense. Dr. Furnas became C.A.L.'s first Director when the Research Laboratory was given to Cornell University by the Curtiss-Wright Corporation at the end of 1945. A nonprofit organization, C.A.L. now has a $13,000,000 backlog of research contracts and has completed more than 1,000 projects valued at $65,000,000. It carries on 140 to 150 projects each year and employs 400 engineers and scientists. About 95 per cent of its work is for the Government.

• **Eastern Air Lines, Inc.,** has announced its choice of the Douglas DC-8 for the "jet age." The 550-m.p.h. transport will carry 100 passengers on luxury flights or 130 passengers as a super air coach. Six of Eastern's DC-8's, to be delivered beginning May, 1959, will be powered by Pratt & Whitney J57 engines; the next 12 planes will have the more powerful J75 engine. Altogether, Eastern plans to spend $165,000,000 on 26 DC-8's, including eight on option, and spares. The jet transports will shrink Eastern's New York–Miami run to 2 hours 19 min.

• **Elastic Stop Nut Corporation of America** announces a new series of locknuts with improved tensile strength at elevated temperatures. Using A286, a stainless-steel alloy, the high-temperature locknuts open new fastening design possibilities in jet engines and aircraft. The A286 alloy has better stress rupture performance and relaxation characteristics than present high-temperature fastening

materials such as Type 347 stainless. A wide variety of nut shapes will be manufactured from A286.

• **Ethyl Corporation** has devised a new, simple method of testing the color of aviation gasoline. Producers will be given glass discs setting standard minimum and maximum intensities for the five colors used in aviation gasoline grades. The testing method has been approved by the Navy Bureau of Aeronautics.

• **Fairchild Engine and Airplane Corporation . . .** Combat and training safety characteristics of the Fairchild C-123 assault transport have been greatly improved by the installation of completely external and jettisonable fuel tanks.

In drop tests conducted first over Chesapeake Bay and later at Wright-Patteron AFB, flight crews released the nacelle-mounted main fuel tanks and the pylon-mounted auxiliary tanks at various altitudes and air speeds and with varying fuel loads. All tests were photographed in slow motion for analytical purposes.

Both the Air Force and Fairchild expressed satisfaction with the operation of the jettison system. They found, for example, that the C-123 can release its fuel cells just before touchdown on an assault-type landing without exposing plane, crew, or passengers to fire hazards. If the transport's tanks should be hit and set afire by enemy guns, the damaged cell or cells could be dropped immediately before fire spread to other parts of the plane.

On the C-123 now being delivered to troop carrier units of the 18th Air Force, all gasoline is carried in the external nacelle and auxiliary tanks rather than in internal wing cells. Considerably less tank area is thus exposed to gunfire.

The nacelle tanks, located just aft of the engine firewalls, have self-sealing linings, and each of these cells has a usable fuel capacity of about 730 gal. The auxiliary tanks, pylon-mounted beneath the wing farther outboard, hold about 450 gal. each.

All four cells are fastened to the wing with quick-release bomb-type shackles. The jettisoning of each tank is individually controlled by a release switch on the overhead instrument panel in the flight compartment. . . . Fairchild has authorized the Royal Nether ands Aircraft Factories Fokker to start conversion engineering on the F-27 Friendship turboprop transport and plans to manufacture the 40-passenger, 270-m.p.h. airplane for delivery toward the end of 1957. . . . The Fairchild Engine Division, anticipating many new uses for small turbojet engines in missiles, target drones, and piloted aircraft, has issued a booklet describing the J44 engine, which has 1,000 lbs. thrust and was the first bantam-weight jet in the United States.

• **Fletcher Aviation Corporation** is manufacturing large jettisonable wing tanks to be used on Air Force B-47 heavy bombers. Each tank has a fuel capacity of 1,700 gal. . . . Ten Fletcher FU-24 utility planes were recently delivered and demonstrated at an airport in Hamilton, New Zealand, with much official publicity. They will be used for aerial top dressing in a land fertilization program under-

an important new drafting technique
24 COLORS—$1.50 PER DOZEN, LESS IN QUANTITY
possible only with
MARS-LUMOCHROM
All colors blueprint perfectly, making color-drafting possible.
MARS-LUMOCHROM does not fade
. . . does not smear . . . is waterproof
. . erases perfectly . . . keeps finest point
Send for free sample
STAEDTLER also proudly introduces the Mars-Pocket-Technico for field use, the Mars "Draftsman's" Pencil Sharpener with the adjustable point length feature, and the efficient, clean Mars lead sharpener. All available—along with the established standards: Mars-Lumograph black graphite drafting pencils, Mars-Technico lead holder and leads, and Tradition-Aquarell painting pencils—at all leading art material and drafting supply dealers.
J.S. STAEDTLER, INC. HACKENSACK, NEW JERSEY

taken for the benefit of New Zealand's farmers.

• **Flight Refueling, Inc. . . .** A refueling unit with rate of flow several times that of the hose reel unit now in production has been developed for jet tankers used in refueling high-speed jet bombers and fighters. The equipment has passed laboratory tests and will be tested in flight this winter.

• **The Garrett Corporation . . .** The AiResearch Aviation Service Division has contracted to build custom lounge interiors for Douglas DC-7C's ordered by Pan American, Braniff, Swissair, Canadian Pacific, and Panagra air lines. The various interior designs are chosen by each air line from a number of styles offered by Douglas. The order from Pan American is for 26 lounges, consisting of two- and three-place sections, desks, and cabinets.

• **General Electric Company . . .** An airplane, complete with engines, that is still in the idea stage can now be given a simulated flight test on an electronic calculator in $^1/_{30}$ the time required by any other system for calculating combined engine and air-frame performance. Engineers who devised the system at G-E's Aircraft Gas Turbine Division in Cincinnati said it not only could save tremendous amounts of engineering and testing time but might save millions in development money, since faulty design features or mismated air frames and engines can be detected before the airplane is built. The system consists of a new method of transferring air-frame and engine performance information to computer cards and a method of setting up the calculator so that it can digest the information on these cards. Time required to put the data on cards and to make the simulated flights will vary according to the complications of each airplane. It may take 3 weeks to complete the cards but, at most, only a few hours to get all the answers on the proposed airplane's performance. Under G-E's previous system, a set of computer cards describing air-frame performance and a set describing engine performance had to be fed alternately into the calculators, and operators had to stop each time to transfer by hand air-frame performance onto the engine cards and engine performance onto the air-frame cards. The new system allows the set of cards representing air-frame performance and the set representing engine performance to be fed into the calculator at the same time. Then the calculator, guided by directions on both sets of cards, calculates the performance of the proposed airplane. During the process the machine draws on engine performance information whenever it is directed to do so by the air-frame performance cards. There is more choice in getting the type of information desired with the new system. Designers seek such answers as engine power, operating limits, and rate of fuel consumption at any airplane speed and altitude. . . . A new bulletin describing G-E's silicone-rubber-insulated, high-temperature aircraft wire may be obtained from the Construction Materials Division, Bridgeport, Conn. The wire has high flame and oil resistance, high tensile strength and elongation, and good cold-temperature characteristics.

• **General Precision Equipment Corporation** announces the election of George Link to the Board of Directors. Mr. Link is Vice-President of Link Aviation, Inc., which was acquired by General Precision a year ago.

• **G. M. Giannini & Co., Inc. . . .** A 1-year test of a new type of contract between this company and Redstone Arsenal, Huntsville, Ala., has shown savings to the customer of $16^1/_2$ per cent in money and 60 per cent in delivery time. The new contract form calls for a given number of instrument parts to be manufactured and kept available in a given year. When the customer determines a specific need, the parts can be assembled quickly to meet that need. From the manufacturer's viewpoint, this has the advantage of making possible large-scale production of parts on an orderly basis, with only minor peaks of activity when assembly must be performed. President Gabriel M. Giannini, AFIAS, said he believed the "stockpile contract" was applicable outside the instrument industry and that he wanted to broadcast the idea because he thought its wide application by other companies would result in substantial savings to the Government. . . . A flight-angle computing system with no moving parts or vacuum tubes has been announced by the Air-Borne Systems Division. Designed as a cruise control aid for optimum fuel economy in military and commercial aircraft, it utilizes a differential pressure pickup probe to sense the angle of attack. By adding a second computer, it is possible to provide pilot indication of angle of yaw.

• **Goodyear Aircraft Corporation** is expanding its staff at the Litchfield Park, Ariz., plant to handle subcontracts on the Boeing B-52 bomber. The company is currently manufacturing air-to-air refueling tanks for the KC-97 and canopy assemblies for the B-47.

• **Grumman Aircraft Engineering Corporation** has contracted to build a $75,000 supersonic wind tunnel at the Polytechnic Institute of Brooklyn's Aerodynamics Laboratory in Freeport, Long Island, N.Y. The wind tunnel and its one-story brick building will be completed in May, and Grumman will operate the tunnel with a permanent staff under a 5-year lease, with an option to renew for 2 years. Upon termination of the lease, the tunnel and building will become the property of Polytechnic Institute. By arranging to use the Laboratory's air supply, Grumman eliminated the necessity of installing compressors, storage tanks, and a dryer, thus saving a year's time.

• **Harvey Aluminum Division of Harvey Machine Company, Inc. . . .** Wide extrusions are being pushed by the Product Development Department because they offer increased strength and rigidity, sealing properties, and weight-saving, in addition to reducing assembly time. Wide profile extrusions can be considered as sheet or plate incorporating integral stiffeners and structural members, produced all in one piece at one time. In the aircraft manufacturing field, Harvey recommends them for skin and floor sections and for wing, fuselage, tail, and bulkhead assemblies.

• **Hydro-Aire, Inc. . . .** Electro-Aire, Inc., a subsidiary, has become an operating division of Hydro-Aire. Located in North Hollywood, Calif., Electro-Aire manufactures fractional horsepower motors for aircraft applications.

• **Industrial Sound Control, Inc.,** of Hartford and Rockville, Conn., has been purchased by Koppers Company, Inc. The business is now operated as the Industrial Sound Control Department of Koppers' Metal Products Division, with headquarters in Baltimore. The department is under direction of Richard D. Lemmerman, TMIAS, while Carl W. Lemmerman, AFIAS, acts as consulting engineer and special representative on contract sales. Both were principal owners of the original company.

• **The Glenn L. Martin Company** has formed a subsidiary, Rias, Inc., to conduct research in basic science. George M. Bunker, President of Martin, is also President of Rias. Welcome W. Bender, MIAS, has been elected Vice-President and a Director. The Board of Directors also includes William B. Bergen, AFIAS, George S. Trimble, Jr., MIAS, and Edward G. Uhl, MIAS. Mr. Bender, who was formerly Manager of Martin's Electronics Department, is organizing the Rias laboratory and assembling its staff of scientists. The research program will include both theoretical and experimental studies which will in no way be tied to Martin product development or production-line problems. Among the first studies contemplated is a theoretical investigation of general relativity and unified field theories as they are related to the theories of gravity, electromagnetism, and possibly subatomic particles. Also under consideration are (1) an investigation of the scientific areas which might be involved in manned transport in outer space and (2) research in the fields of atomic and subatomic physics, materials in solid state, fluid dynamics, electronics, and many areas related to the biophysical sciences.

• **North American Aviation, Inc.,** has formed two new divisions. The Autonetics Division, Downey, Calif., will handle engineering and manufacturing operations in the electromechanical field. In 10 years of guided-missile development, North American's work in electromechanics has grown into an operation employing nearly 8,000 persons. The Autonetics Division is engaged in the development and production of automatic navigational systems for missiles and aircraft, autopilots, automatic flight control systems, air-borne armament control systems, radar systems, analog and digital computers, data-processing equipment, and precision automatic controls for machine tools. Present products include the fire control system for the F-86K, electromechanical flight stabilizer controls for the F-100, and the NADAR air-borne tape recorder. The Rocketdyne Division, an outgrowth of the company's Propulsion Center, has been established to

Captain Eddie Rickenbacker chooses

Allison Prop-Jet Power for Eastern Air Lines

☆ *Serving more United States cities than any other airline* ☆

Eastern's new Lockheed Electras—world's fastest, smoothest, most luxurious airliners—will fly at well over 400 miles an hour!

AFTER years of engineering research covering all types of aircraft power units, Eastern Air Lines has selected Allison Prop-Jet engines and Aeroproduct Propellers for our fleet of 40 new radar-equipped Lockheed Electra airliners.

This decision represents a great step forward in Eastern's progress into the jet age, and reflects our conviction that Allison Prop-Jet power, a product of General Motors, is the most efficient and dependable engine-propeller team for the new Lockheed Electra.

This new Allison engine harnesses the vast power of a modern gas turbine to a propeller. It uses less fuel than a straight jet, yet it enables aircraft to fly faster with greater payload than any other propeller-type aircraft engine in commercial use today.

Allison-powered Electras will be in service on Eastern Air Lines routes in the Fall of 1958. Flying at speeds of well over 400 miles an hour, these 66-passenger airliners will offer unprecedented smoothness of flight, a new standard of quiet, restful comfort, and the highest degree of dependability.

We of Eastern congratulate General Motors on this great achievement in aircraft power, an achievement that will help bring the untold benefits of modern air transportation to more millions of people in the years to come.

Chairman of the Board, EASTERN AIR LINES

I AM happy to announce that Captain Eddie Rickenbacker, one of the most highly respected figures in aviation and dean of the air transportation industry, has chosen Allison Prop-Jet engines and Aeroproduct Propellers for Eastern's new fleet of Lockheed Electra airliners.

Captain Rickenbacker's decision is a magnificent tribute to General Motors and the Allison Prop-Jet engine, the first gas turbine engine to receive Civil Aeronautics Administration approval for commercial service.

The Allison Prop-Jet engine is the most advanced power plant of its type and is backed by more than 7 million hours of turbine engine flight time in military aircraft.

In Allison Prop-Jet power, General Motors again demonstrates its leadership in the development of power for all kinds of transportation. In aviation, in motor vehicles, in locomotives and in marine engines, GM has gained the confidence of millions of people who daily depend upon GM power units.

In air transportation, Eastern Air Lines has earned and held the confidence of the traveling public for over 27 years. General Motors and Allison Division are proud to join Captain Rickenbacker and Eastern Air Lines in this great contribution to the future of commercial aviation, national defense and the progress of American-designed and American-powered aircraft.

President, GENERAL MOTORS CORPORATION

The Allison Prop-Jet engine is backed by more than 7 million hours of turbine engine flight time—experience where it counts most—in the air.

ALLISON
PROP-JET POWER
ALLISON DIVISION OF GENERAL MOTORS
Indianapolis, Indiana

BUILT IN THE UNITED STATES FOR THE NEW ERA IN AIR TRAVEL

Architect's sketch shows how the multimillion-dollar engineering research center planned by Northrop Aircraft, Inc., will appear when completed at Hawthorne, Calif. Northrop's engineering talents will be centralized in the air-conditioned two-story building at the right and in the attached six-story structure. The low building at left will house a new employees' cafeteria.

carry on research, development, and manufacture of large rocket engines and related items. The Rocketdyne Division, which has 4,000 employees, has moved to a new $3,475,000 building in the Canoga Park section of Los Angeles.

• **Northrop Aircraft, Inc.** . . . Work has been started on a $5,335,000 engineering research center at Hawthorne, Calif., which will consolidate virtually all the company's engineering activities under one roof. An engineering test laboratory, a low-speed wind tunnel, and a new cafeteria also will be built this year, raising the total cost of new construction to about $8,000,000. The air-conditioned engineering center, with 250,000 sq.ft. of floor space, will consist of two floors and an adjoining six-story structure. It will be an integrated, functional building of steel, concrete, aluminum, and glass, designed with flexibility and allowance for economical future expansion. Modular partitions, wiring, and floor slabs are standard. Northrop also will supervise construction for the Air Force of a guided-missile engine test facility and an environmental and electrical test laboratory. Both facilities will be located in Hawthorne and used by Northrop under Air Force contracts. The engine test cell will be completely enclosed by concrete walls and sound mufflers. The new engineering center and other buildings represent the first phase of a long-term master plan which has been prepared to consolidate and improve Northrop's facilities.

• **Pan American World Airways, Inc.** . . . Richard S. Mitchell has been elected Vice-President in charge of the Guided Missiles Range Division, located at Patrick AFB, Cocoa, Fla.

• **Piasecki Helicopter Corporation** . . . In its first public flight demonstration December 6, the turbine-powered YH-16A helicopter showed its ability to hover at various altitudes, maneuver in any direction including backward, and climb steeply and fly fast. About 250 invited guests witnessed the demonstration at Philadelphia International Airport. Built for the Air Research and Development Command of the Air Force, the 40-passenger, 16-ton craft uses two Allison XT38 turboprop engines to turn its tandem rotors. Each rotor is 82 ft. in diameter and has three blades. In flight tests, the company said, the Turbo Transporter (YH-16A) has proved its ability to fly 150 m.p.h. and to maintain altitude with one engine dead. It is capable of autorotative flight with both engines off. The use of gas-turbine engines in helicopters offers several advantages. They are smaller and lighter than piston engines of comparable power; easier to service and maintain; and require no cooling fan, extensive oil system, nor warm-up time. Vibration and noise are greatly reduced. Unlike piston engines, which have a high rate of fuel consumption at high power, the turbine is most economical at high speed. If a helicopter must operate at high speed for long periods or spend much of its time in take-off and hovering (as in rescue work), the turbine offers an advantage. These factors, when combined with the lower cost and greater safety of jet fuel, offset the generally higher fuel consumption of the turbine, according to Piasecki. The YH-16A, an improvement over the piston-engined YH-16, is in turn serving as a prototype for the larger, higher-powered YH-16B, which Piasecki plans to manufacture as the production version of the Turbo Transporter. It is designed to carry 69 troops and will have Allison T56 turboprop engines.

• **Republic Aviation Corporation** . . . The F-105A fighter-bomber has made a number of test flights at Edwards AFB and was reported to have passed Mach 1 on its first flight October 22. It has a Pratt & Whitney J57 engine. . . . Drag parachutes being installed in F-84F jet fighter-bombers and RF-84F photo-reconnaissance planes enable them to roll to a stop on a normal landing in only 2,400 ft., Republic says. That is 1,000 ft. shorter than a normal landing run without the chute. Without any use of brakes, an F-84F using the chute in a test slowed to a safe turn-off speed of 20 knots in 4,500 ft. The new equipment will facilitate braking on slick, wet, or icy runways and will permit the F-84's to land at smaller air bases throughout the world. "Retrofit" kits will be shipped out for Thunderstreaks and Thunderflashes already in service. Two safety features have been incorporated to make sure the chute would blow clear of the airplane in the event of its release in flight as a result of battle damage. One is an "ice-tong" connection that is kept unlocked in flight, so that the chute is not attached to the plane until the pilot closes the tongs upon landing. The other is a "weak link" designed to fail if the plane is flying faster than 220 knots. Still more safety is provided by the fact that the equipment operates from the aircraft battery, thus permitting use of the drag chute in power-off landings. It also can be used in wheels-up landings. When the airplane is rolling at 130 knots, the chute exerts a decelerating force of about 8,000 lbs.

• **Ryan Aeronautical Company** . . . The Firebee remote-controlled jet target drone is being put through operational suitability tests by the Air Force at Holloman AFB and by the Navy at Point Mugu, Calif. . . . Ryan has constructed a large extension to its Jet Engine Parts Building, adding 45,000 sq.ft. of floor space. . . . The complete inventory of Navion factory-built parts, with the rights and production tooling needed to manufacture additional parts, has been sold by Ryan to Tubular Service and Engineering Company, of Houston, Tex. It is estimated that about 2,000 Navions, which were built by both Ryan and North American Aviation, Inc., are still flying.

• **Socony Mobil Oil Company, Inc.** . . . Socony Mobil Laboratories, of New York, has made a grant of $5,000 to Rensselaer Polytechnic Institute to support research aimed at solving problems involved in the friction and lubrication of solids.

• **United Air Lines, Inc.** . . . The apprentice mechanic training program at the San Francisco maintenance base has produced its first two graduates. Forty-one apprentices are presently enrolled. . . . United has issued a booklet on operations, entitled *Cleared for Take-Off*.

• **United Aircraft Corporation** . . . Hamilton Standard Division is planning a major expansion at its plant in Windsor Locks, Conn. A new one-story structure will add 210,000 sq.ft. of manufacturing space, and the addition of a third floor to the present two-story office building will give 40,000 sq.ft. more office space. Both improvements will be completed this year and will be financed by the company, according to the announcement.

• **Vard, Inc.,** has designed a five-cylinder sleeve-valve engine for use as an airborne power plant.

• **Vickers Incorporated** announces a new series of rotary-input, constant-gain steering valves for nose wheel steering applications requiring automatic castering control. One feature of this new development is the packaging of all the control elements into one housing, reducing weight and maintenance. . . . Vickers conducted its first Turbojet Engine Hydraulics Symposium February 2–3 at the Park Shelton Hotel, Detroit. The four sessions covered these topics: (1) Turbo jet Engine Actuation Systems, (2) High-Temperature Components and the Use of Fuel for Cooling, (3) Reliability and Testing of Engine Hydraulic System Components, and (4) High-Temperature Hydraulic Fluids.

HIGHER SPEEDS

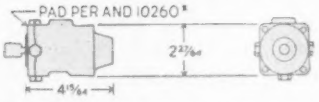
SMALLER ENVELOPES

LIGHTER WEIGHTS

HIGHER CEILINGS

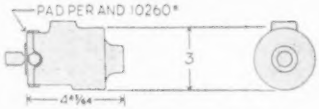
A New Series of Fixed Displacement Pumps That Check Out on the Points You Want Most!

MODELS 65F005



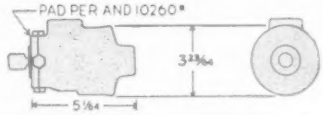
Rated Capacity: 0.5 gpm @ 1500 rpm.
Max. Continuous Speed: 10,000 rpm.
Continuous Pressures: 1500 psi and 3000 psi.
Weight: 31 oz.

MODELS 65F010



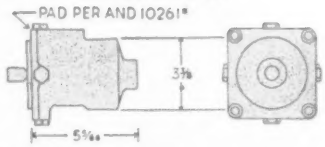
Rated Capacity: 1.0 gpm @ 1500 rpm.
Max. Continuous Speed: 10,000 rpm.
Continuous Pressures: 1500 psi and 3000 psi.
Weight: 3.2 lb.

MODELS 65F015



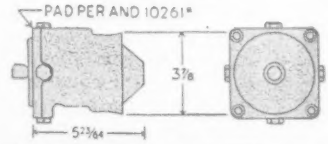
Rated Capacity: 1.5 gpm @ 1500 rpm.
Max. Continuous Speed: 10,000 rpm.
Continuous Pressures: 1500 psi and 3000 psi.
Weight: 4.0 lb.

MODELS 65F020



Rated Capacity: 2.0 gpm @ 1500 rpm.
Max. Continuous Speed: 7500 rpm.
Continuous Pressures: 1500 psi and 3000 psi.
Weight: 5.5 lb.

MODELS 65F030



Rated Capacity: 3.0 gpm @ 1500 rpm.
Max. Continuous Speed: 7500 rpm.
Continuous Pressures: 1500 psi and 3000 psi.
Weight: 6.0 lb.

Other mounting flanges and port arrangements available.

STRATOPOWER
HYDRAULIC PUMPS

The 65F Series STRATOPOWER Hydraulic Pumps pack more power than ever into extremely small envelopes . . . check the drawings! These Fixed Displacement Pumps operate at higher speeds . . . check the figures!

The 65F Series Pumps feature a piston actuation mechanism which is unaffected by fluid temperatures or inlet pressures. They will operate with reservoirs pressurized to over 80 psi absolute, yet do not require pressurization for altitude operation.

ENGINEERS

Exceptional opportunities for men of imagination to express new ideas in the design and development of Hydraulic Components. Company expansion and progress in this growing industry promise rewarding futures for engineers who qualify. Write, giving experience and full details.

WATERTOWN DIVISION
THE NEW YORK AIR BRAKE COMPANY
STARBUCK AVENUE • WATERTOWN • N Y.
INTERNATIONAL SALES OFFICE, 90 WEST ST , NEW YORK 6, N. Y.

IAS SECTIONS

Meet Your Section Chairman

John H. Boucher

Texas Section

John H. Boucher, whom his friends call "Jack," has worked his way up in the IAS, serving as Membership Chairman, Secretary, and Vice-Chairman prior to becoming Chairman of the Texas Section for the year 1955–1956.

Jack joined Chance Vought Aircraft, Incorporated, in Stratford, Conn., in November, 1946, as a Liaison and Field Engineer. In 1951 he was promoted to Assistant Project Engineer and was assigned to the close-out of the F4U-7 Corsairs and to the origin of the XF8U-1 day-fighter program for 2 years. He is now Supervisor of the Controls and Hydraulic Design Group, having received this promotion in March of 1955.

Jack moved to Texas with Chance Vought in February, 1949. He lives in Arlington with his wife and small daughter.

During the years previous to his employment with Chance Vought, Jack attended Georgia Institute of Technology, majoring in Aeronautical Engineering and graduating with a B.S. in 1943. He entered the USAAF Officers Candidate School at Miami Beach, Fla., and won the Military Award as the youngest Cadet Corps Colonel of any class when he graduated as a Second Lieutenant in March, 1944.

Jack served as an Engineering Officer for 3 months in the United States and 2 years overseas in the Southwest Pacific Theater, where he worked in Light Bombardment and Air Service Command Units with A-20, B-25, and B-24 aircraft. Receiving his honorable discharge in September, 1946, he married his college fiancée a month later.

Atlanta Section

A. Howard Hasbrook, Director of Aviation Crash Injury Research, a project of Cornell University, spoke at the November 3 meeting.

Declaring it was safer to fly than to ride in an automobile, he pointed out that the aviation industry has been working intensively for several years, by means of crash studies, to reduce injuries and fatalities. Investigations are made of all survivable accidents, with special emphasis on exactly what happened, the magnitude of the forces involved, the types of injuries sustained, and the causes of the injuries.

A veteran flier himself, Mr. Hasbrook is a member of the NACA's Flight Safety Subcommittee and serves as a consultant to safety engineers and research groups in the Government and in the aircraft and air-transport industries.

Since most aircraft structure is relatively strong, he said, the problem of crash survival has become one of preventing passengers from striking parts of the airplane, or preventing parts from striking passengers. Following crash studies, new information is given constantly to designers, with the resultant development of items such as shoulder harness, collapsible seats, stronger seat attachments and belts, and improved cabin padding and insulation.

The Nike

Chicago Section

A capacity crowd of 150 members and guests met in the cafeteria of Argonne National Laboratory (AEC) for dinner on November 9. After dinner the Section Chairman, J. W. Pocock, called the meeting to order. Richard Schram and Jack Goodman introduced the speaker, Gen. M. S. Carter, USA.

General Carter reviewed the history of the Nike guided-missile program from its conception to the achievement of an operational standard vehicle. He particularly stressed the continuing design improvements in the Nike system which keep it abreast of anticipated speed and range developments in likely targets. After the talk, a film on Nike development was shown. This film depicted tests performed against radio-controlled drones of the B-17 and B-29 class.

The IAS members and guests were then divided into two groups and conducted on a tour of the Nike installation. The first stop afforded a look at the receiving and inspection area where newly received missiles are uncrated and inspected. Next, the fueling procedure was demonstrated. Members of the fueling crew wore rubberized clothing for protection against nitric acid. From this demonstration, the group was taken to the underground storage area and permitted to examine the missiles at close range. Exit from the underground magazine was made by the same elevator used to transport the missiles to the launchers. Several such elevator-to-launcher operations were demonstrated. The tour ended with a visit to the control area, where the radar and computing equipment were discussed. At this time a mock attack was staged, and tracking of both the target and the Nike missile was demonstrated.

The visiting engineers were especially impressed with the efficiency and fine training exhibited by the Army crews.

Upon completion of the tour, the visitors were guests of the Army for coffee and cake in the mess hall. During this coffee break a question-and-answer period was held.

HARRY WIANT, *Secretary*

Cleveland-Akron Section

On November 15 Rear Adm. James S. Russell, Chief of the Bureau of Aeronautics, addressed 160 members and guests at the Hotel Hollenden in Cleveland. He spoke on "The Role and Success of Seaplanes in the U.S. Navy."

Before the meeting, the IAS members had toured the Air Force Heavy Press Forge Plant that is operated by the Aluminum Company of America.

Admiral Russell remarked that during the 1940's the seaplane, with its conventional deep hull and high frontal area, had lagged behind the progress of the land planes with their retractable landing gears and improved streamlining. However, recent hydrodynamic advances in seaplane hull design have opened the door to major improvements in the aerodynamic design of sea planes. He expressed the opinion that as airplanes become larger and larger these major advances in aerodynamic design, combined with a complete shift in structural design considerations, should enable the seaplane to surpass the performance of the land plane while still retaining its enviable mobility.

Admiral Russell further stated that the most important problems presently obstructing ultimate tactical, strategic, or commercial use of the seaplane are those of divorcing it from archaic beaching equipment and improving the re-

(*Continued on page 71*)

Rear Adm. James S. Russell, AFIAS, Chief of the Navy's Bureau of Aeronautics, outlined the role of tomorrow's seaplane in an address before the Cleveland-Akron Section.

sistance of its many components to salt water corrosion. He added that a seaplane must be made a seaplane—that is, it must cease to be half dry and half wet. It must be made to live in its environment and to thrive on it. He felt that the realization of that goal would result in a bright future for the seaplane.

▸ On October 18 the Cleveland-Akron Section held a meeting at the Sleepy Hollow Golf Club. Prior to the meeting the IAS members were conducted on a tour through the B. F. Goodrich Research Laboratory in Brecksville, Ohio.

Following dinner, Col. R. C. Gibson, Deputy Chief of Guidance and Control Division, Air Research and Development Command, USAF, presented a comprehensive paper on "Some Principles of Missile Guidance." He traced the history and development of missile guidance systems from their concept in 1925 when it was suggested that rockets could be made to fly along a searchlight beam by means of monitoring photoelectric cells. He reviewed the principles of guidance systems currently used for surface-to-air, air-to-air, and long-range surface-to-surface missiles.

Particular emphasis was placed on the magnitude of the problems involved in obtaining accurate guidance to the target. In the case of long-range surface-to-surface missiles, around which most of this discussion centered, the problem is further complicated by the fact that as the missile travels to its target it passes through an appreciable arc around the earth's circumference. Thus to maintain its proper course, a continuous reorientation of the missile's vertical axis is required.

Colonel Gibson indicated that in spite of the many problems to be overcome, the Air Force is achieving an appreciable degree of success in the development of guidance systems for current missiles.

WILLIAM A. FLEMING, *Secretary*

Hagerstown Section

J. Henry Reisner, of Hagerstown, spoke at the November 15 meeting in The Museum of Fine Arts. He described the highlights of his recent trip to Europe and compared the English-manufactured air frames and engines to those produced in this country. Thirty-five members and guests attended. Chairman Allen Clopper introduced the speaker and announced subjects planned for future meetings.

C. L. CHUMLEY, JR.
Secretary-Treasurer

Safe Design

Los Angeles Section

Brigadier Gen. J. D. (Smoky Joe) Caldara addressed the November 17 dinner meeting on the subject "The Importance of Design to Accident Prevention." He was introduced by the guest chairman, Lewis Caplan, Director of the Aviation Safety Division of the University of Southern California. General Caldara presently is the Director of Flight Safety Research for the United States Air Force. He recalled the historical trend of a decreasing accident rate in the Air Force, dating from World War I, but noted that the trend was broken on three major occasions.

The first break was the "Air Mail Incident" of 1932, the second accompanied the rapid build-up of the Air Force prior to World War II, and the third came with the World War II demobilization period. The accident rate increased during these periods because of poor training and maintenance as a result of commitments beyond the capability of the Air Force. In general, as the total amount of flight time increased, the accident rate decreased—"the more we fly the safer we fly." The fatality rate has shown a gratifying decrease through the years. However, the ratio of fatalities to major accidents has increased from the order of 1 in 13 to 1 in 5, and this General Caldara attributed to the higher speeds of modern airplanes.

Of particular significance in the data presented was the fact that accidents are not more probable on any particular day of the week, at any particular time of the year, or in any special weather conditions.

He noted that jets fly 29 per cent of the total hours put in by Air Force planes but contribute two-thirds of the total number of accidents. Nearly half the jet accidents were attributable to pilot errors. He noted that the pilot-error category included—in addition to plain mistakes—cases where pilots could not perform in a satisfactory manner because of unduly difficult conditions. Material failures accounted for 23 per cent of the accidents, and the remaining accidents were distributed among unknown cases amounting to 24 per cent and several minor categories. Unexpectedly, only 45 per cent of jet accidents occurred during landings, compared to 55 per cent for nonjet aircraft. In-flight accidents accounted for 32 per cent in the jets and 22 per cent in the nonjets. Take-off accidents accounted for 16 per cent in jets and 11 per cent in nonjets.

General Caldara noted that while airplanes have improved by an astonishing amount in the last 50 years, the man who must fly them has remained unchanged. Since both man and machine must act in concert to maintain flying safety, the greater performance potentials of present-day airplanes must similarly be counterbalanced by better design toward safety if the accident rates are to decrease. One important factor in the combination is human perception time. He noted that jet aircraft flying toward each other on a collision course would have to perceive each other at a distance of over 2 miles in order to avoid a head-on collision. A margin of safety must be designed into the airplane equipment above and beyond the pilot's capabilities in order to provide for fatigue and adverse operating conditions. The design requirement included phases of instrument reliability, maintenance accessibility, and the strength and austerity of the pilot.

In conclusion, he stated that while no airplane is deliberately designed with accident-inducing features, many airplane designs include accident-inducing features. Airplanes earn the nickname of a bird or a beast; which are you designing?

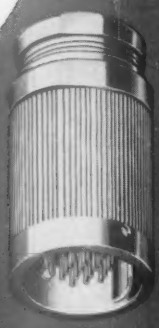
Chairman George Mellinger directed a lively question-and-answer discussion at the conclusion of the talk and had to terminate the meeting with many questions unanswered.

▸ The speaker at the October dinner meeting of the Los Angeles Section was Lawrence P. Green, Chief Aerodynamicist of North American Aviation, Inc. He presented a paper classified as "confidential" on the "Design and Development History of the F-100 Airplane." George Mellinger, Section Chairman, presided and Brig. Gen. J. Stanley Holtoner, Commander of the Air Force Flight Test Center at Edwards AFB, served as Guest Chairman.

Mr. Green dealt with the conceptual history of the F-100 and its develop-

DEPENDABLE PERFORMANCE

miniature size



AMPHENOL

MINIATURE AN-TYPE CONNECTORS

actual size—11, 14 & 24 contacts

Are you working with miniaturization programs? Achieve full-size efficiency with AMPHENOL'S *MS series of Miniature AN-type connectors. Check these design advantages:*

- *⅓ to ½ the weight of standard AN*
- *Pressure-proof; waterproof, mated or apart*
- *Tamper-proof, unitized female inserts*
- *3 polarizations for gang mounting*
- *Positive, moisture-proof cable strain relief and clamp*
- *5, 9, 11, 12, 14 or 24 contacts*
- *Aluminum shells, gold-plated contacts, blue dielectric*

POTTING *These miniature connectors may also be ordered in constructions for potting. Perfected by* AMPHENOL, *potting is the modern, positive method of moisture-proofing.*

AMERICAN PHENOLIC CORPORATION
chicago 50, illinois

AMPHENOL

AMPHENOL CANADA LIMITED
toronto 9, ontario

ment as an advanced aerial weapon from the F-86 series. He noted that the enlarged flight spectrum of the F-100 resulted in problems that had previously been ignored and that new techniques were developed for their solution. The configuration was discussed, and modifications resulting in substantial performance increases were described. The talk was followed by a showing of some outstanding pictures of the airplane.

R. G. FULLER, *Secretary*

▶ On December 3, about 400 members, wives, and friends of the Section attended the annual holiday dance at the IAS Building. Brightly colored bells, balls, and ribbons dressed the hall in the spirit of Christmas. Air transportation took a new turn as reindeer pulled the Wright brothers' airplane carrying a load of balloons which were dropped on the crowd. A lively six-piece combo featured all styles of music to stir the bones of the most sedentary engineer. During intermission, two live turkeys and an electric mixer were given as prizes. "And so Santa said as he rode out of sight, 'A Merry Christmas to all, and to all a good night!'"

BEN R. RICH AND C. F. BRANSON
Social Affairs Committee

▶ A tour of the Jet Propulsion Laboratory of the California Institute of Technology was held on November 30 for the Los Angeles Section. The tour included inspection of the 12-in. Mach 4 wind tunnel, observation of a basic research test at the 20-in. supersonic tunnel, discussion and display of the solid propellants and rockets test area, and inspection of the Central Recording Station. W. H. Padgham, of the Jet Propulsion Laboratory, organized and directed the tour. It was closed by a talk given by W. H. Pickering, Director of the Laboratory, in which he discussed the development of the installation from its inception to today.

▶ "Recent Developments in the Aerodynamics of Wings for High Speed" was the subject of a talk by Robert T. Jones of Ames Aeronautical Laboratory, NACA, on November 29. He presented his talk to an audience of 130. Methods of maintaining high lift-to-drag ratio in subsonic flow and of minimizing drag in the transonic regime were reviewed. Utilizing results from linearized supersonic flow such as the Ursell-Ward reciprocity theorem, the speaker established criteria for maximum drag for a system having both lift and volume. Certain drag reduction methods were applied to wing body systems in supersonic flow.

JEROME L. FOX
Specialist Meeting Coordinator

▸ On November 15, Dr. Richardson of the Ramo-Wooldridge Corporation presented a paper on "A Theory of Turbulent Flames" to a group of 40. He discussed the available experimental results of turbulent combustion processes and the development of theories based on the flame front stretching concept and the concept of small-scale turbulent transport. He then sketched his own mathematical treatment of the flame stretching concept and contrasted the results with those of previous analyses.

FRANK E. MARBLE
Specialist Meeting Coordinator

Flight Control

Niagara Frontier Section

The November 9 meeting of the Niagara Frontier Section featured a discussion of the evolution of flight control. Phillip Whitaker, an Assistant Director of the M.I.T. Instrumentation Laboratory, read portions of Charles S. Draper's Wilbur Wright Memorial Lecture entitled "Flight Control," which Dr. Draper presented before the Royal Aeronautical Society last spring.

In this paper Dr. Draper reviews the development of flight controls throughout the history of aviation. Particular emphasis is placed on the attitude of engineers and scientists in the aviation field, prior to the successful flight of the Wright brothers, with respect to the stability and control of aircraft. The commonly held opinion was that aircraft must be inherently stable in all respects and that the pilot need exercise a guidance and steering function only. The inability to design for complete inherent stability was one of the primary reasons that successful flight had not yet been achieved.

Dr. Draper advances the interesting thesis that the Wright brothers' prime contribution to aviation, and one which has hitherto been overlooked, was their deliberate design and construction of an aircraft which was inherently unstable, but which was provided with the necessary degree of stability by the pilot himself. Other investigators had attempted to build completely stable airplanes and were unsuccessful. The Wright brothers, however, perceived that the pilot himself could stabilize the aircraft (with sufficient practice), and therefore deliberately designed their airplane to be unstable so that, as they stated, it would show "the minimum of response to the changing air currents." Dr. Draper further points out that power plants, wing sections, structural design, etc., were individually developed to the degree necessary to permit powered flight prior to the Wright brothers' successful flight. What was needed, however, to make a successful flight was the integration of these techniques and the realization that inherent stability was not an absolute necessity.

The Wright brothers were particularly inspired by Lilienthal in this respect and made a careful study of his gliding flights in which he was able to impart stability to the machine by shifting his body weight. The Wrights reasoned that Lilienthal learned by sheer skill to control and stabilize his glider, even though he actually had a very small amount of flying time in the craft over a period of several years. The Wrights therefore constructed a glider which they tethered in the wind—and practiced control. This provided them with considerable information on the characteristics of, and the necessity for, an adequate control system and considerable practice in stabilizing the aircraft.

The presentation by Mr. Whitaker stimulated considerable discussion and comment on the part of the audience, indicating that there was a great interest in this subject and also that several of the people present were familiar with the Wright brothers' work, having spent appreciable time reading and studying their papers. The gist of the discussion and comment was that many doubted the contention that the Wright brothers purposely designed their airplane to be unstable.

A reading of the Wright brothers' papers brings to light several control problems which are discussed by Wilbur and which were obviously the result of static instability. These occurred during the early gliding flights, and the solution to these difficulties was to make the craft more stable. It was agreed that the Wright brothers were apparently the first to provide an airplane with a control system having an adequate effectiveness for the degree of stability present. It was felt that the Wrights' craft was certainly inherently stable in some respects but different from other aircraft in that it had an effective control system. It was further suggested that probably the Wright brothers' real contribution was the first realization that a human pilot could, through an adequate control system, provide an aircraft with adequate stability.

In the 1903 era a large number of proposed aircraft included in their design some form of artificial stabilization system, largely mechanical, for the automatic control of the craft's attitude, speed, etc. This indicated that men's thinking led them to believe that the only way to achieve complete stability was through the use of mechanical stabilizing devices. The realization on the part of the Wrights that this stability could be obtained through the pilot himself acting as a stabilizing means, via an adequate control system, was the idea which essentially made successful flight possible. Considerable discussion seemed to center around the proper definition of stability and control. It was felt that possibly all points of view—i.e., Dr. Draper's and those of the many discussors at the meeting—were correct depending upon what one's definition of stability is. Even the modern airplane is not completely stable in the strictest sense with respect to all axes and possible modes of motion.

This meeting was extremely well attended, with between 75 and 85 members and guests present. Thanks are due to Mr. Whitaker for giving us this presentation, ably substituting for Dr. Draper who was taken ill at the last minute and could not be with us.

DAVID WHITCOMB, *Secretary*

Rocky Mountain Section

The fledgling Colorado Section, with members from Denver, Colorado Springs, and Boulder, has changed its name to Rocky Mountain Section. The following officers were elected at the second meeting on December 2:

Chairman—Major Vincent J. Bracha, Project Engineer, Hq., Air Defense Command, Ent AFB.

Vice-Chairman—Alison M. Arnold, Chief Aerodynamicist, Stanley Aviation Corporation, Denver.

Secretary—Arthur W. Gilmore, Assistant Professor of Aeronautical Engineering, University of Colorado.

Treasurer—Major William R. Fuchs, Professor of Aeronautical Engineering, U.S. Air Force Academy.

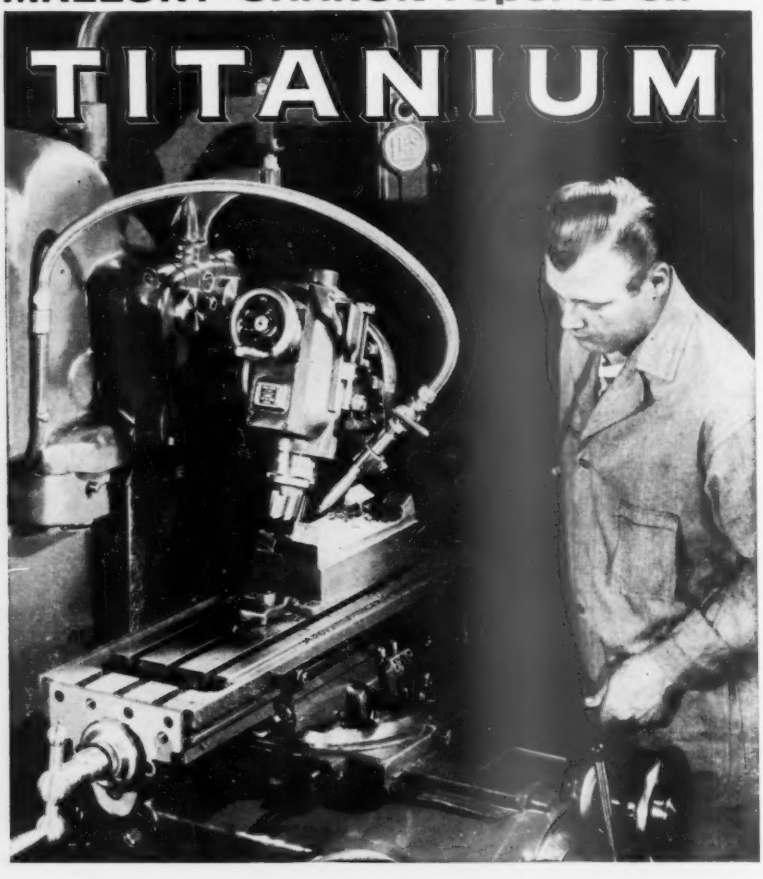
The Advisory Committee consists of Major Gen. Marshall S. Roth, USAF; Lt. Col. Gerhardt C. Clementson, USAF; Lt. Col. William A. Larsen, USAF; Harold W. Sibert, Alan F. Bonnalie, Richard H. Frost, W. G. Purdy, and Richard B. Bosworth. K. D. Wood was named Area Representative to the IAS Nominating Committee.

St. Louis Section

The Education Committee, headed by Harold Hertenstein, has announced April 25 as the date for oral presentation of the winning papers in the Annual Student Paper Competition. Announcements of the competition have been mailed to colleges in 15 mid-Western states.

Current activities of the Education Committee include the preparation and distribution of a list of aeronautical consultants available for high school and college "career days," assisting Student Branches to build up their

MALLORY·SHARON reports on



GUARANTEES
faster titanium machining

• Mallory-Sharon now guarantees that MST titanium and titanium alloy mill products contain no more than 1/10 of 1% carbon, maximum. Since larger percentages of carbon result in formation of hard carbides which greatly reduce machineability, this guarantee assures you that MST material has the optimum machining characteristics obtainable.

Thus you can machine Mallory-Sharon titanium faster, save production time and cost. In addition, this low carbon level assures improved notch toughness, fatigue properties, and uniformity of material. This new quality standard, another first from Mallory-Sharon, is made possible by "Method S" vacuum double melting.

Call us for your present requirements—or future plans—in titanium. For bulletin on Mallory-Sharon's new Titanium—6% Aluminum-4% Vanadium alloy write Dept. D-2.

MALLORY-SHARON TITANIUM CORPORATION, NILES, OHIO

MALLORY Ti SHARON

programs, inviting high school counselors and teachers to attend IAS Section programs, cooperation with the Educational Committee of the St. Louis Engineers Club, and encouraging students and young engineers to participate in IAS activities. The other members of the committee are Fred Doblhoff, Robert Killoren, Richard Trefny, and John Locke.

A membership drive based on the "individual approach" has brought in more than 120 applications. Posters, Section literature, and printed materials supplied by IAS Headquarters in New York are being used in the campaign. The Membership Committee consists of Leo Mirowitz, Chairman, and B. C. Boulton, H. H. Cole, O. B. McBee, H. C. Rechtien, P. T. Homsher, W. Mengel, T. M. Bellan, F. H. Roever, and M. G. Walker.

FREDERICK H. ROEVER
Recording Secretary

Organization Meeting

San Antonio Section

More than 100 persons interested in aviation gathered at Kelly AFB October 27 to organize the San Antonio Section of the Institute of the Aeronautical Sciences. This becomes the IAS' twenty-seventh Section.

San Antonio, Tex., long a town endowed with military aviation activities, proved to be a strong focal point for aviation in general.

At the dinner were representatives from 16 organizations including Convair, A Division of General Dynamics; Pratt & Whitney; Boeing Airplane Company; Allison Division of General Motors; Aeroproducts; Curtiss-Wright; Fairchild Engine Division; Hamilton Standard; Continental Division of the Military Air Transport Service; the 1700th Air Transport Group; Southwest Research Institute; and The University of Texas.

Bill Clegern, Manager of the San Antonio office of Convair, was the master of ceremonies.

Following a discussion of the IAS as a working organization and outlining the activities of other IAS Sections, Mr. Clegern introduced Major Gen. Clements McMullen, USAF (Ret.) and a founder of the IAS, who discussed what the IAS has meant to him and what it can mean to each individual interested in the aeronautical sciences.

The principal speaker was Col. Claude W. Smith, Commander of the 1700th Air Transport Group of MATS. Colonel Smith discussed the service testing of the turboprop transport aircraft assigned to his group. At the present time, this unit is obtaining operational information on the Allison YT-56 turboprop engine and the aero-

New! AC speed sensing control

...for jet engines

...for turboprop engines

- *accurate within ½ of 1% of operating speed settings*
- *no attention required between engine overhauls*
- *exceeds all requirements of Mil-E-5009A*

1. Through Drive Shaft
2. Standard AN Drive Pads at both ends
3. Snap-Action Switches
4. Precision Flyweight Assembly

The most sensitive control of its kind yet produced for use on gas turbine engines!

Now, you can automatically control ignition at set engine speeds . . . control fuel flow . . . operate hydraulic bleeder valves . . . actuate afterburners . . . or any of a dozen other operations important to the functioning of a gas turbine engine.

But, the amazing part is this: *This new AC Speed Sensing Control is so carefully engineered, and so precisely built, that it will "repeat" within a tolerance of less than ½ of 1%.*

What's more, this small-size, lightweight control will operate switches at as many as four different predetermined speeds. It is designed to withstand high engine vibration, is ignition-proof, will hold calibration and operate without attention for periods exceeding engine overhauls.

AC can design a Speed Sensing Control to fit the specific requirements of any aircraft or industrial application in the gas turbine field. If you have a speed sensing problem, write direct to AC in Milwaukee. Your inquiry will receive a prompt reply.

AC QUALITY PRODUCTS

GM GENERAL MOTORS

AC SPARK PLUG THE ELECTRONICS DIVISION OF GENERAL MOTORS • FLINT, MICHIGAN • MILWAUKEE, WISCONSIN

ANNOUNCING

a new long life BG spark plug

The new BG platinum electrode spark plug – RB 39R – has now been CAA approved for Pratt & Whitney's R4360, R2800, R2000, R1830 series engines.

Designed in the tradition of quality established by BG, a leader in the field since 1917, the RB 39R features a new anti-fouling ceramic core design, an all weather top, and a new ground electrode design for long life.

As an added service, BG maintains a facility for factory overhaul of all platinum electrode spark plugs. Factory overhaul combines economy with long life and trouble free service.

the name that is first with aircraft engineering and maintenance personnel

For information concerning the RB 39R and other BG products, write to:

THE BG CORPORATION
321 BROAD AVENUE · RIDGEFIELD, NEW JERSEY

prop propeller installed in two Convair 340 test-bed aircraft. Colonel Smith's organization is also testing two Boeing YC-97 aircraft equipped with Pratt & Whitney T-34 turboprop engines driving Curtiss propellers. Late in 1955, Colonel Smith expected to receive two Lockheed YC-121F aircraft with T-34 engines and Hamilton Standard propellers.

Highlighting the discussion was a chart showing the actual comparison in operation of a turboprop Convair on a route flown by a conventional Convair 340. The savings in time, even on a flight of less than 1 hour's duration, was noted with interest.

In discussing the simplification of engine controls, Colonel Smith stated that flying safety had been greatly increased in the turboprop aircraft by eliminating the necessity for multiple controls. With the turboprop, one power lever for each engine performs the work of several controls on piston engines.

Another highlight of the evening was a working cutaway model of the Allison T-56 turboprop engine that was brought to San Antonio especially for the IAS organization meeting.

J. W. DRAPER

San Diego Section

Commander M. Nelson Piller, USN, Commanding Officer of Jet Squadron VF-112, spoke on "U.S. Navy Carrier Operations" at a confidential technical meeting November 29. His paper covered the carrier and its mobility, the carrier's weapon (its aircraft), and the integration of these two. Both present and future naval carrier operational problems were discussed. Commander Piller has a long history in naval carrier operations. His squadron is presently stationed at Mitscher Field, San Diego, and participated in the Tachens evacuation.

The following Chairmen have been appointed for standing committees: Bill Nugent and John Herald, Cochairmen, Program Committee; Harry Matteson, Building Management Committee; John Hopkins, Membership Committee; Roy Elliott, Library Committee; Fred Landgraf, Historical and Museum Committee; Bill Chana, Publicity Committee; Jim Bowyer, Student Aid Committee; and Bill Immenschuh, Nominating Committee.

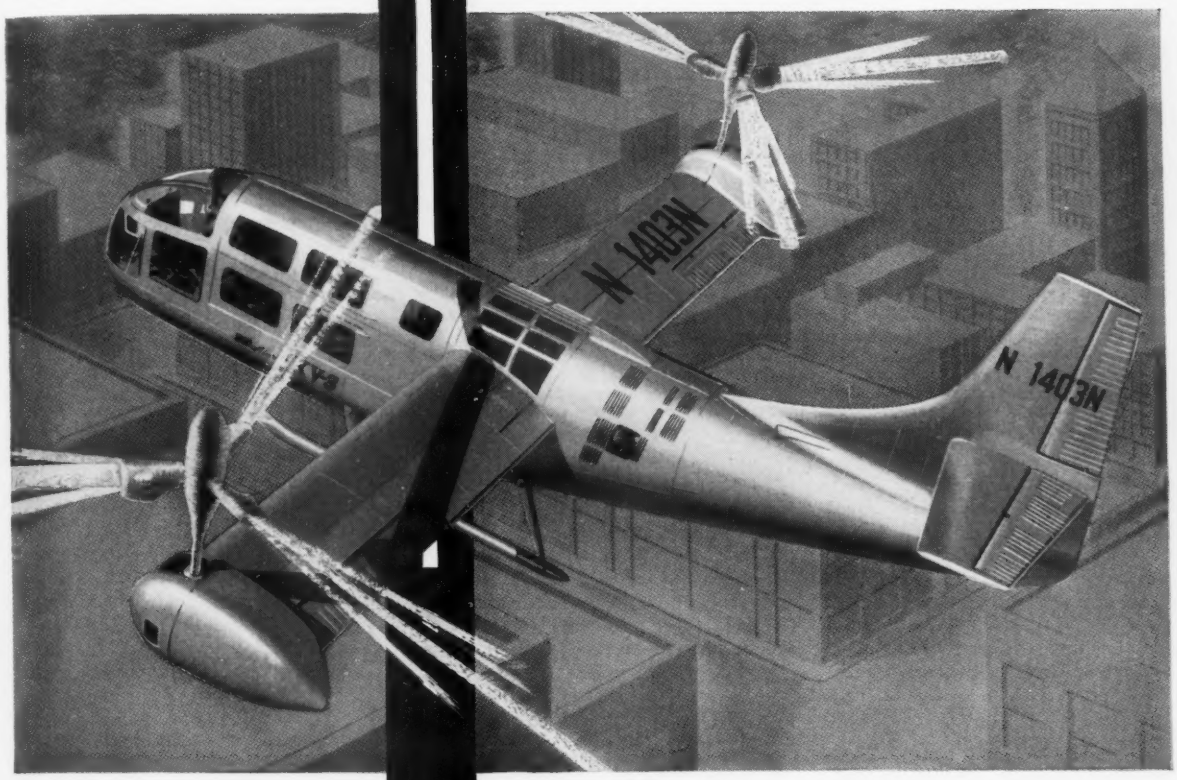
R. A. FUHRMAN
Corresponding Secretary

Pilot Escape

Texas Section

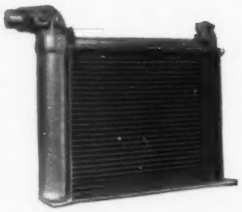
About 300 persons attended the October 28 meeting, held in the ballroom of the Baker Hotel. The guest

COOL COMMUTER!



Harrison Cools Revolutionary New Bell Convertiplane

Take off from the back yard! Land on the roof top! And waste no time between! The revolutionary new Bell Convertiplane is a helicopter at the field, a plane in the sky. This means highly variable conditions for engine temperature control. Harrison engineering came up with the answer, with controlled cooling that equalizes the variables, maintains correct engine temperatures under all flight conditions. Design of special cooling equipment for one of the world's most versatile aircraft is another example of Harrison leadership in temperature control. Let Harrison's broad experience and extensive research facilities help you. Whenever you have a temperature-control problem, look to Harrison for the answer.



GM GENERAL MOTORS

Temperature control is our business at Harrison. Harrison heat exchangers are known the world over for efficiency and reliability And Harrison keeps pace with new needs with the most intensive temperature-control research in the industry.

TEMPERATURES MADE TO ORDER

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

Lt. Col. John P. Stapp, USAF, who won the John Jeffries Award in 1952, talks with four engineers of Chance Vought Aircraft, Inc., after inspecting the cockpit and escape features of the Navy's Crusader at the Dallas plant. From *left to right* are: J. W. Konrad, Chief Test Pilot; Robert C. Donovan, AFIAS, Chief of Design; Colonel Stapp; John H. Boucher, MIAS, Supervisor of Hydraulic and Controls Design, and Chairman of the Texas Section; and Charles O. Miller, MIAS, Flight Safety Engineer, and Program Chairman of the Texas Section.

speaker was Lt. Col. John P. Stapp, Chief of the Aero-Medical Field Laboratory at Holloman AFB, N.M.

Other honored guests were C. J. McCarthy, Chairman of the Board, Chance Vought Aircraft, Incorporated; August C. Esenwein, Vice-President and Division Manager, Convair, A Division of General Dynamics Corporation, Fort Worth; R. C. Blaylock, Vice-President—Engineering, Chance Vought Aircraft; F. W. Davis, Chief Engineer, Convair-Fort Worth; J. R. Clark, Assistant Chief Engineer, Chance Vought; Brig. Gen. John D. Ryan, Commanding Officer, 19th Air Division of the Strategic Air Command, Carswell AFB; and Dr. Hall Shannon.

Colonel Stapp was introduced by the Program Chairman, C. O. Miller, Flight Safety and Cockpit Design Engineer, Chance Vought. His subject for the meeting was "Escape from High-Performance Aircraft." He also showed movies of the test work that was done at the Edwards and Holloman bases.

The first movie showed the tests conducted to determine the *g* forces the human body can endure. In December, 1947, Colonel Stapp took his first "sled" ride, a one-rocket spurt that reached 90 m.p.h. The next day he fired three rockets and went twice as fast. By June, 1951, he had done about all that could be done with the test setup at Edwards AFB. He had been subjected to stresses up to 35*g*. This was more than twice what experts had thought the human body could withstand. The practical limits of human endurance to *g* forces were established as a result of these tests as being 50*g* for $^1/_4$ of a sec, building up at a rate of 500*g* per sec.; 40*g* for $^1/_5$ of a sec, building up at 1,500*g* per sec., and 25*g* for 1 sec., building up at 600*g* per sec.

The next movie showed the tests being conducted at Holloman AFB to determine the effects of escaping from aircraft at high speeds. The pictures of his now famous ride in which he accelerated to 632 m.p.h. in 5 sec. and decelerated to a dead stop in 1.4 sec. were shown. During this ride he was subjected to more than 40*g*. The driver of an automobile colliding with a brick wall at 50 m.p.h. would be taking about the same jolt. Also shown were some movies of a faster sled which he hopes to ride at 1,000 m.p.h.

C. L. TURNER, JR., *Secretary*

Tulsa Section

At its November 3 meeting, the Tulsa Section welcomed E. W. Robischon and Paul B. Welles of the national offices of IAS as guests. This new Section has completed organization plans and has launched a membership drive. About 70 members and prospective members attended the dinner meeting.

Mr. Robischon, Manager of the Western Region for IAS, spoke on the aims, activities, and services of the IAS as a national organization. He informed us of the benefits of local section activity to members which include the development of executive ability in committee work and the exchange of technical information of interest to all. He outlined the various grades of membership in IAS and the qualifications for each grade. In conclusion, he offered his assistance to the Tulsa Section whenever needed to obtain worth-while speakers or films suitable for interesting Section meetings.

Mr. Welles, of the New York Headquarters staff, was the second speaker. He explained the role of the Student branches in the national program of IAS, their activities on the local and the regional levels, and their benefits to the higher grades of membership as well as to the students. He told of the regional paper competitions, the Giannini Film List advising where movies may be borrowed for Section and Student Branch meetings, and other IAS publications—including the *IAS Thesis Topics List* and the *Vocational Guidance Manual*—which are available to all grades of membership.

Two movies were then shown. The first was a Douglas film concerning the design and use of the Nike ground-to-air intercepting missile, and the second was a Lockheed film on aeroelastic problems of supersonic wings.

GERTRUDE HILL FILA, *Secretary*

Navigation

Twin Cities Section

The October dinner meeting was held at the Officers Club at Fort Snelling, Minneapolis, with Robert Hoel presiding as Chairman. After calling the meeting to order, he introduced Capt. Martin B. Cahill, MIAS, the guest speaker, who is an Engineering Pilot for Northwest Airlines, Inc.

Captain Cahill opened his subject, "Navigation and Communications Systems in Use by Northwest Airlines," with a discussion of navigation instruments including the periscopic sextant, the radio altimeter, the driftmeter, and LORAN. He then gave a brief outline of the facilities at Wold-Chamberlain Airport and described their functions. Upon conclusion of the discussion, the audience was divided into small groups for an inspection tour which included a Boeing Stratocruiser cockpit, the Northwest Airlines flight planning center, the CAA air traffic control rooms, and the Wold-Chamberlain control tower.

The periscopic sextant is an optical instrument which can be used to determine the true azimuth and altitude of a heavenly body. Thus a check can be made on the aircraft compass, and the position of the aircraft can be determined. The radio altimeter is a type of vertical radar which is used to determine the true altitude of an aircraft with respect to the terrain immediately below. Aircraft drift is determined by the use of a driftmeter which provides a direct reading of drift angle if the earth is visible. This instrument contains an optical grid that is aligned parallel with the earth's surface by the operator and held in position by a self-erecting gyroscope.

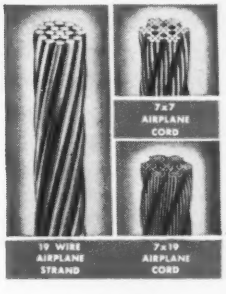
How to arrest a jet safely

U.S. Navy Jet landing on carrier.

Put yourself in the pilot's seat of a super-speed jet plane landing on the deck of an aircraft carrier. It's an exciting moment. When you hook the arresting cable will you stop safely—or plunge over the side into the drink?

To give these cables utmost safety, only the finest steel is used in their construction. They combine strength and resiliency to absorb the shock of jet fighters or medium bombers. Special cables were developed for this purpose by American Steel and Wire Division and they have proved highly successful in operation.

Other USS American Aviation Products include control cables, springs, stainless steel, bars, welded fabric for airports and Cyclone Fence. Write for complete information.



AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL
GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

USS AMERICAN AVIATION PRODUCTS

UNITED STATES STEEL

KEARFOTT FILLS THE BILL

AIRCRAFT AND MISSILE CONTROL SYSTEMS
BILL OF MATERIAL
ITEM
PURCHASE FROM
✓ GYROS — KEARFOTT
✓ SYNCHROS — KEARFOTT
✓ SERVO MOTORS — KEARFOTT
✓ PRECISION TACHOMETERS — KEARFOTT
✓ MECHANICAL COMPUTER COMPONENTS — KEARFOTT
✓ INDICATORS — KEARFOTT
✓ PRECISE GEAR TRAINS — KEARFOTT
✓ AMPLIFIERS — KEARFOTT
REMARKS:
Specify KEARFOTT for all Servo System Components and Gyros!

Long years of experience in the development and production of precision servo system components enables Kearfott to offer you the *right* component for every function in your servo system. Kearfott components are available in a wide range of miniature and sub-miniature sizes, light weights and high accuracies. Many components are suitable for high temperature applications. Engineering data sheets fully describe the many Kearfott Components in production.

Send for Bulletin describing components of interest to you.

ENGINEERS
Many opportunities in the field of precision components and systems are open. Write for details today.

Kearfott

A SUBSIDIARY OF GENERAL PRECISION EQUIPMENT CORPORATION

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

Sales and Engineering Offices: 1378 Main Avenue, Clifton, N. J.
Midwest Office: 188 W. Randolph Street, Chicago, Ill. South Central Office, 6115 Denton Drive, Dallas, Texas
West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

The electronic long-range navigational system known as LORAN provides readings to the navigator which correspond to lines of position on LORAN charts. These lines are used in the same way as the lines of position obtained from celestial observations. However, the LORAN system may be used in any kind of weather and provides approximately the same accuracy as fixes from celestial observations within the service distance of a LORAN chain (approximately 800 nautical miles by day and 1,500 nautical miles at night).

The Northwest Airlines flight planning center processes all flight plans and maintains radio contact with planes in flight. In fulfilling this function, a number of factors must be considered: the determination of the allowable load according to the particular aircraft and its destination, the weather (N.W.A. maintains its own meteorology station which is used in addition to the U.S. Weather Bureau), ship and crew scheduling, etc.

The CAA flight control rooms have charge of all instrument flying in the Minneapolis district (an area including Minnesota, North and South Dakota, and parts of Iowa and Montana). They are in charge of aircraft until the airport control tower takes over and sees that the proper flight patterns, etc., are maintained.

The control tower maintains contact with planes near the airport—informing them of position, weather conditions, and other aircraft in the vicinity—and specifies the runway to be used.

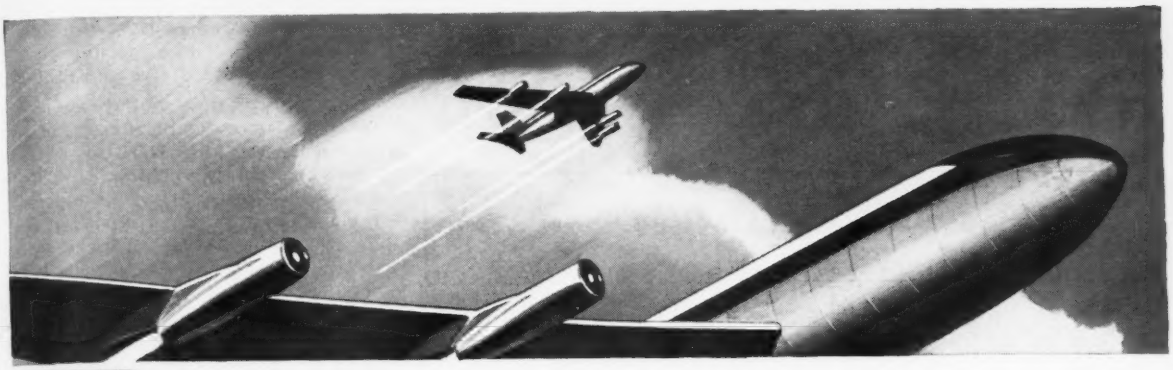
H. C. JOHNSON
Recording Secretary

Wichita Section

McConnell AFB, Wichita, Kan., was host to the Wichita Section on November 16.

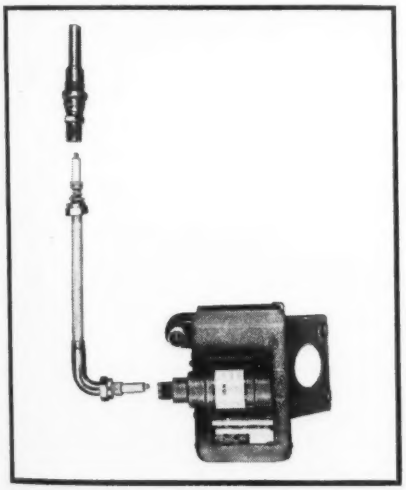
Those attending the meeting gained an excellent insight into flight safety activities through a talk presented by Major Clarence H. Mills, Wing Safety Officer, McConnell AFB, on "The Air Force Aircraft Accident Prevention Program."

Major Mills exhibited data indicating steady, marked reductions in the Air Force airplane accident rate, with the exception of the war years, down to the year 1954, when the rate of major accidents was 18 per 100,000 flying hours. He pointed out, however, that the greatly increased cost of both military aircraft and the training of pilots makes imperative even further reduction in the aircraft accident rate. Since at the present time about 50 per cent of all



Bendix.. *Ignition Leader in research engineering, manufacturing and service!*

FIRST in JET ENGINE IGNITION



Only Bendix provides the complete ignition system for jet engines—Ignition Unit, Igniter Plug Leads, Igniter Plugs and Control Harness.

Today's acceptance of Bendix as the leader in jet engine ignition is but an extension of the confidence that the aviation industry has always placed in Bendix as the foremost designer and builder of ignition for every plane and purpose.

The ability of Bendix to consistently come up with the right answer to ignition problems is based on unmatched experience in ignition research, engineering, manufacturing and service.

That's why from blueprint stage to field service follow-through you can depend on Bendix—the most trusted name in ignition—for the best in jet ignition for today's planes or tomorrow's plans.

SCINTILLA DIVISION,
BENDIX AVIATION CORPORATION,
SIDNEY, NEW YORK

Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES: 117 E. Providencia Avenue, Burbank, California • 512 West Avenue, Jenkintown, Pennsylvania • Stephenson Building, 6560 Cass Avenue, Detroit 2, Michigan • 5906 North Port Washington Road, Milwaukee 17, Wisconsin • American Building, 4 S. Main St., Dayton 2, Ohio • 8401 Cedar Springs Road, Dallas 19, Texas • Boeing Field, Seattle 8, Washington • 1701 "K" Street, N. W., Washington 6, D. C.

Bendix
SCINTILLA DIVISION
Bendix AVIATION CORPORATION

Air Force accidents are attributed to pilot error, it is felt that improved crew training is a major avenue toward increased flight safety.

An Air Force film, *Know Your Air Rescue Service*, was presented following Major Mills's talk.

S. H. HINTON, *Secretary*

STUDENT BRANCHES

Agricultural and Mechanical College of Texas

At the November 1 meeting, Chairman Robert C. Barlow introduced the speaker, Fred E. Weick, Director of the Personal Aircraft Research Center at Easterwood Field.

Mr. Weick, a Fellow of the IAS, spoke to an audience of 44 members on the development of the W-1 and W-1A airplanes which eventually led to the Ercoupe design. He said this development took place in the early 1930's while he was employed by the National Advisory Committee for Aeronautics at Langley Field, Va.

The speaker pointed out that the purpose of the W-1 was to test experimentally new ideas in light-plane design. The innovations included a tricycle landing gear with a steerable, castering nose gear; devices for stallproof and spinproof flight; a glide-control flap; and a single control coordinating rudder and ailerons. These four elements were the result of a period of research effected by Mr. Weick and other engineers working for the NACA. Until the flight testing phase was reached, however, the entire project was a private venture.

After explaining the program briefly, Mr. Weick discussed the tricycle landing gear with particular reference to its development on the W-1. Included in this part of his talk were some advantages of this type of gear, particularly that of stability on the ground and its aid to the pilot in landing.

HARLESS R. BENTHUL, *Secretary*

The Catholic University of America

Nicholas R. Gallipoli, Chairman, called the first meeting to order on October 27 and introduced the new officers for the academic year: Ziegler White, Treasurer; Peter Bogan, Corresponding Secretary; and James R. McGrath, Recording Secretary.

Max M. Munk, Head of the Department of Aeronautical Engineering, then addressed the group, pointing out the growing need and importance of the engineering profession, with emphasis on aviation's requirements. Dr. Boehler and Mr. Emanuel, both of Catholic University's staff, spoke briefly on the objectives of the IAS Student Branch.

Applications for membership were accepted, and an unofficial count shows an increase of 50 per cent in active membership. Speakers for future meetings were discussed.

The idea of a dance to be held in the wind tunnel was suggested and discussed. Further discussion was put off until more research on the innumerable problems associated with such a venture could be conducted.

JAMES R. MCGRATH, *Secretary*

Georgia Institute of Technology

On November 29 the IAS Student Branch had a joint meeting with the American Society of Mechanical Engineers, with over 100 attending to hear Robert L. Lichten speak. Mr. Lichten is Chief Experimental Project Engineer of Bell Aircraft Corporation's Helicopter Division in Fort Worth, Tex.

Speaking on "The Spectrum of Direct-Lift Aircraft," he discussed the five principal types of direct-lift aircraft—namely, the helicopter, convertiplane, vertical take-off (with propeller), vertical take-off (jet), and the ducted fan. The purpose of the direct-lift aircraft is to take off vertically with no ground run. Mr. Lichten illustrated his talk with slides and concluded with a film showing the first experimental attempts to take off vertically in the XV-3 convertiplane and another Bell film entitled *Ability Unlimited*.

▶ At the November 28 meeting, 46 members saw the films *Sabre Jet F-86E* and *Exercise Test Drop*. An equal number viewed the film *We Saw It Happen* at the November 14 meeting.

▶ Thirty-nine members attended the second fall meeting of the Student Branch. The speaker was Robert F. Stoessel, Manager of the Sales Engineering Department of Lockheed Aircraft Corporation's Georgia Division.

Mr. Stoessel defined the sales engineer as either a salesman who knows engineering or an engineer who knows selling. A sales engineer's first job is to sell the product and keep it sold, and secondly to assist the manufacturer in producing a better product. A salesman must inform the manufacturer as to the changes that a customer desires and must also sell to an existing customer the changes that are being made.

In the aircraft industry there are not many customers. Mr. Stoessel suggested that there are perhaps only 50 to 75 customers in the whole world. This makes the competition keen among manufacturers. The cost of aircraft is so high, with possibly thousands of dollars' difference between one airplane and another, that a special kind of salesmanship is needed.

The aircraft salesman must sell his products scientifically; that is why he must either be an engineer or know engineering. The airplane must be worth the money paid for it—it must have top performance, the operating costs must be at a minimum, and the profit to the customer must be at a maximum. It is the salesman's job to assist the manufacturer to produce such an aircraft and then to sell it.

Mr. Stoessel mentioned some of his own experiences as a sales engineer. He showed colored slides of charts and graphs which the sales engineer uses in selling airplanes.

ROBERT E. DOWNS, *Secretary*

Institute of Technology, USAF

The Student Branch met August 23 to hear a lecture on "Military and Engineering Aspects of Satellite Systems" by Darrell Romick of Goodyear Aircraft Corporation. The lecturer presented physiological elements, aerodynamic and structural considerations, ion-accelerator-type and nuclear propulsion, trajectory and orbital control, equipment, tracking, and other engineering problems encountered in launching and placing a satellite in an orbit. The talk was illustrated by slides.

Mr. Romick has had considerable experience in guided-missile work at Goodyear during the past 10 years and has published several technical papers.

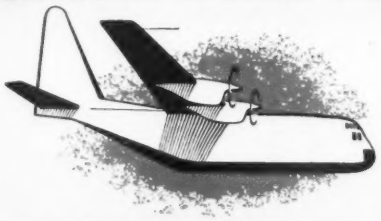
The lecture was attended by well over 100 engineers, not only ITUSAF students but also engineers from other parts of Wright-Patterson Air Force Base.

Following the lecture, a meeting of student members was held for the purpose of electing officers for the 1955–1956 school year. The new officers are: President, First Lt. John Wittry, USAF; Vice-President, Capt. Ko Sameshima, USAF; and Secretary-Treasurer First Lt. Douglas S. Egan, Jr., USAF.

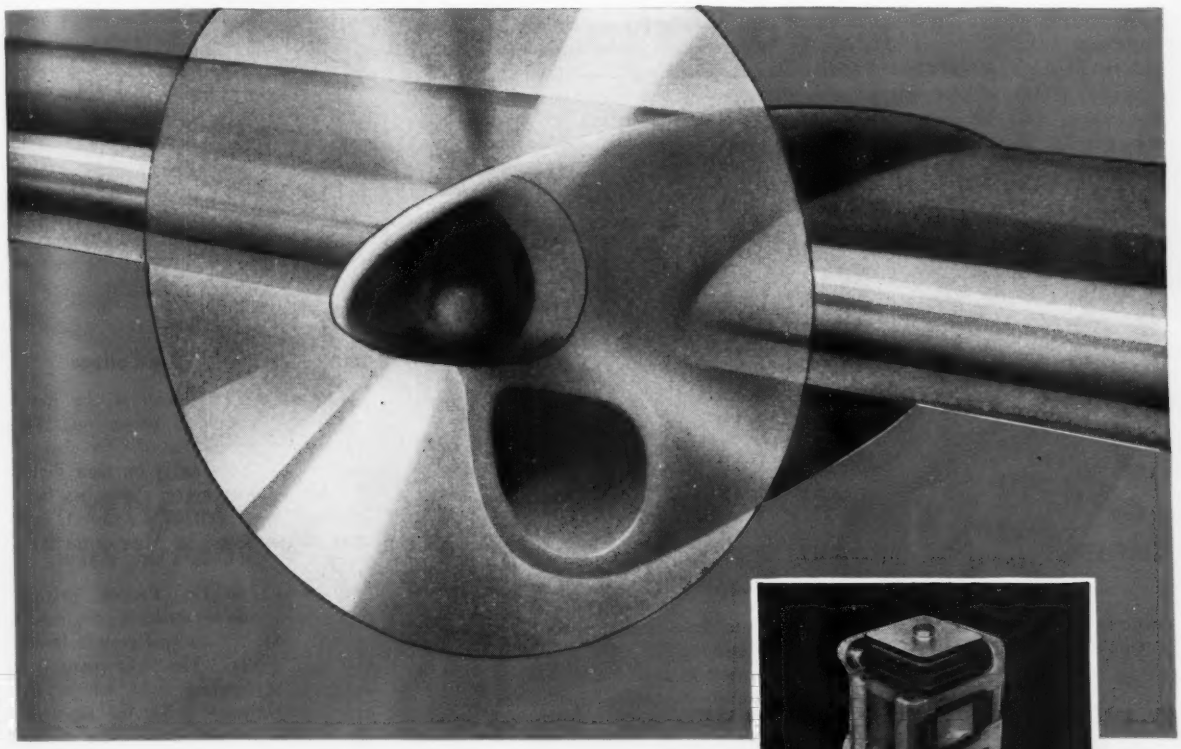
The name of the Student Branch was changed from USAFIT to ITUSAF (Institute of Technology, USAF), in accordance with the change of name of the school.

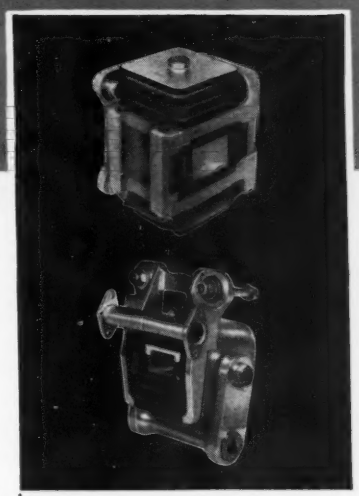
DOUGLAS S. EGAN, JR., *Secretary*

ANOTHER SPECIAL VIBRATION PROBLEM SOLVED BY LORD



the case of the "hot turbo-prop"





The outstanding LM-200 turbo-prop aircraft engine mountings, designed and built for long, high-efficiency performance under extremely hot operating conditions.

Turbo-props "pack a lot of power" in providing the R3Y-1 and C-130 with their outstanding performance. But these same power plants presented two major problems affecting efficient operation. The first was to isolate heavy propeller disturbance, and the second to control engine vibration under extremely hot conditions—with temperatures (at the mounting points) as high as 475°.

LORD engineering and research produced the best answers to these problems with LORD LM-200 MOUNTS on the C-130 and LORD J-5216-SA MOUNTS on the R3Y-1. These mountings are only two of the many successful solutions that LORD has produced for vibration control in the aircraft field. On light planes and heavy transports, on "hot" high-speed planes and hovering helicopters—LORD products have materially reduced vibration and improved performance.

LORD's 30-year record of accomplishment in vibration control, coupled with exceptional engineering, research, and production are the down-to-earth reasons why LORD is equipped to provide the best solutions to problems involving aircraft vibration control.

LORD MANUFACTURING COMPANY • ERIE, PENNSYLVANIA

LOS ANGELES, CAL. HOllywood 4-7593 | DALLAS, TEXAS PRospect 7996 | DETROIT, MICH. TRinity 4-2060 | NEW YORK, N. Y. Circle 7-3326
PHILADELPHIA, PENNA. LOcust 4-0147 | DAYTON, OHIO MIchigan 8871 | CHICAGO, ILL. MIchigan 2-6010 | CLEVELAND, OHIO SUperior 1-3242

LORD BONDED RUBBER

DESIGNERS AND PRODUCERS OF BONDED RUBBER PRODUCTS SINCE 1924

Iowa State College

Ralph Vullos, Director of Convair's supersonic wind tunnel located at Daingerfield, Tex., spoke at the November 8 meeting of the Student Branch.

He described methods and equipment used to record data rapidly in the supersonic tunnel and explained in detail the internal balance system used to obtain the forces and moments exerted on a model during testing. The talk was illustrated with slides, including color schlieren photos of aerodynamic models.

▶ At the October 26 meeting, the members enjoyed two movies taken from a series entitled *Man Will Conquer Space*. These movies were produced by Johns Hopkins University and had appeared on the television program *The Johns Hopkins Science Review*. They featured famous men in the fields of science, medicine, and engineering who were engaged in interplanetary research. These men explained some of the phenomena of outer space and what had been done or was being done to counteract the hazards of space flight. They also outlined some of the suggested methods and procedures for establishing an artificial earth satellite.

During the business meeting, John Furrer was selected to be the aeronautical engineers' candidate for most entertaining engineer, and Bill Anderson offered his services as publicity chairman for the Branch.

ROBERT D. DIGHTON, *Secretary*

Louisiana State University

Six basic films were ordered from the IAS Western Headquarters in Los Angeles to help entertain several non-aero engineering students at the November 29 meeting. This series, entitled *How an Airplane Flies*, opened the door to some elementary aerodynamics for the guests.

The Chairman read a letter from Douglas Aircraft Company, Inc., offering us a speaker for the next meeting. The offer was eagerly accepted.

RUDOLPH BEGAULT
Secretary-Treasurer

Air Flivver

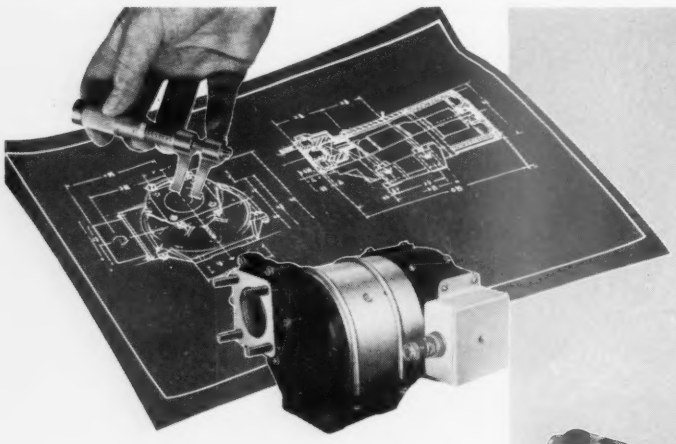
Mississippi State College

August Raspet, Head of the Aerophysics Department, spoke on "The Flivver of the Air" at the October 20 meeting. An authority on slow flight, Dr. Raspet for several years has been conducting an extensive research program for the Navy at Mississippi State College.

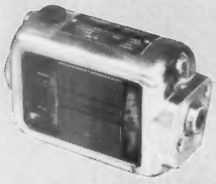
According to Dr. Raspet, private flying has made remarkable progress in recent years, but its real growth lies in the near future. The light plane still demands a landing field which, for practical purposes, is far too large for the average American to have at his backdoor. The real future of the personal aircraft industry lies in the design and production of an airplane which can safely land and take off in small areas and still be capable of economical high speeds in flight.

The problem of short take-off distance was resolved into a simple vector problem of lift, drag, thrust, and centrifugal force during the pull-up. The shortcoming of present light aircraft lies in the insufficient lift and thrust; however, much progress has been made in increasing the lift vector by using boundary-layer control. Dr. Raspet said that, in experiments conducted under his direction, engineers had produced a C_l of 3.95 on a Piper Cub wing using boundary-layer control. The large unsolved problem lies in increasing thrust.

Dr. Raspet showed that an airplane weighing 1,500 lbs. and having a 125-hp. engine could be air-borne after a take-off run of only 40 ft. if the total power of the engine could be converted into thrust. The type of propeller commonly used on light planes is an inefficient means of producing thrust when observed in this light. Dr. Raspet



a motor designed to your exact product requirements

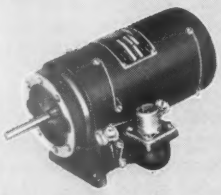


For motor-driven office equipment.

Many manufacturers of motor-driven products have found that the use of a Lamb Electric *special application* motor results in better products and lower costs.

Our high degree of specialization in both equipment and methods provides the advantages of custom manufacture on a volume basis. High quality and controlled costs go hand-in-hand.

We shall welcome the opportunity to demonstrate the benefits of a Lamb Electric special application motor for *your* products.



Aircraft pressurizing pump motor.

THE LAMB ELECTRIC COMPANY • KENT, OHIO
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

KAWNEER METAL BONDING FACILITIES *for assemblies with IMPROVED FATIGUE-LIFE, HIGHER STRENGTH and LOWER WEIGHT*

The use of honeycomb and metal bonded construction has become a necessity for the successful solution of many airframe problems. The pounds saved in floor construction and bulkheads for commercial airliners mean additional range and revenue. The aerodynamic smoothness of external surfaces means more knots, less power, better control, and longer range. The rigidity and light weight can reduce flutter and balance problems while the elimination of stress-raising fasteners minimizes fatigue. Kawneer can be your reliable source for honeycomb and bonded construction.

Kawneer is producing a wide variety of flat and contoured honeycomb assemblies for the airframe industry. In addition to complete sheet metal forming and fabricating facilities, Kawneer has metal bonding equipment that is capable of 650°F. and 200 lbs. per sq. in. which will handle adhesives for higher temperature applications required for future higher speed aircraft. Typical assemblies currently in production for most of the major aircraft producers are trailing edges, airfoil contour trim tabs, floor panels, flight deck tables, access doors and panels and large, contoured wing panels. Kawneer is capable of assisting you in simple or complex, large or small, flat or contoured, organically bonded honeycomb or metal bonded assemblies.

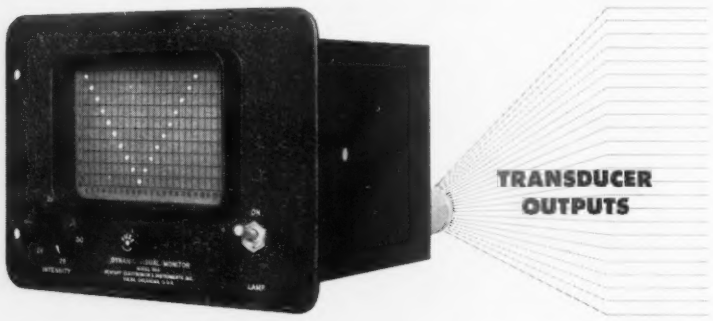
Our engineers can work with you in your design and production problems. Please write, wire or phone.

ENGINEERS! Kawneer offers excellent opportunities for growth and advancement. Bring your family to Niles and enjoy vacationland living. Work in new, modern facilities.

Write for new illustrated Metal Bonding Department descriptive folder.

50TH ANNIVERSARY
Kawneer
General Offices
NILES, MICHIGAN
1906–1956

Century MODEL 20 VISUAL MONITOR



For TEMPERATURE PRESSURE VIBRATION FLOW RADIATION COLORIMETRY CURRENT VOLTAGE

Does your data problem include any of the above? Or anything similar?

The Model 20 Visual Monitor is a completely new concept in multiple data-point indication.

Now you can observe and measure 24 separate data points, simultaneously. No Switching, no commutating, no time lag.

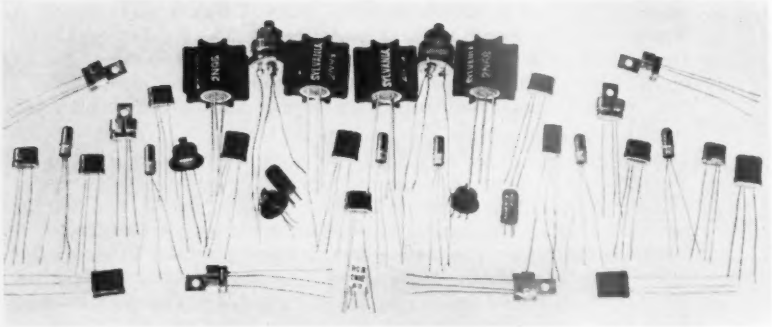
Wherever a graphic display of several quantities will facilitate measurement and control, the Model 20 should be considered.

Utilizing light-beam D'Arsonval galvanometers as the indicating elements, the Visual Monitor permits display of transducer output in an easy-to-interpret, graphic form.

Let us hear from you. We would like to discuss your instrumentation problems with you.

Century Electronics & Instruments, Inc.
1333 No. Utica, Tulsa, Oklahoma

COOLER LIGHTER SMALLER



The application of transistors to the development and design of standard circuits shows an increased tendency towards the acceptance of solid state components for subminiaturization.

Transistors provide the designer with a tangible means of reducing volume, power requirements, and heat dissipation by a large degree. A marked improvement in transistor construction as well as their operating characteristics now permits equipment design without compromise in performance and reliability.

Personnel Inquiries Invited

RADIATION, INC. is proud of the role it is playing in the utilization of transistorized circuitry.

RADIATION Inc. Melbourne, Fla. Orlando, Fla.
Electronics • Avionics • Instrumentation

cited progress which has been made in increasing the efficiency of the propeller as a means of producing thrust. Work done in Germany with a Kort nozzle or ducted propeller was discussed. It was pointed out that static thrust has been increased by 1.6 for a given power setting by using such a device.

Once the future light airplane is in the air, the next problem to be thought of is landing it safely in a small space. Dr. Raspet said that at present this is a serious problem. Boundary-layer control devices can be used to advantage, but in themselves they are not the answer. He said he believed, however, that future technology will solve this problem satisfactorily.

Safer control devices were then discussed. Dr. Raspet's idea is that the future airplane must be controlled in such a manner that the pilot will "drive" the plane rather than fly it. He proposed electrical mechanisms to aid toward this end. An example would be aileron control that would produce a constant bank with a given control position instead of a constant moment such as present control devices produce.

In conclusion, Dr. Raspet predicted that within a few years technology would progress to the point of solving these problems, thus putting the light aircraft industry on a competitive basis with the automotive industry by making safer, faster, and more economical travel available and practical to the general American population. "When that time comes," Dr. Raspet said, "we'll truly have the flivver of the air."

Following his address, Dr. Raspet showed films of his experimental Piper Cub equipped with boundary-layer control.

JULIUS H. LOVE, *Secretary*

North Carolina State College

Seventy aero students, including 25 IAS members, attended the November 8 meeting conducted by Chairman David Gurley.

Charles Lundy, Vice-Chairman, outlined Pledge Week, which is expected to more than double the number of active members.

All activities concerning the Engineer's Fair, originally scheduled for next April, have been shelved temporarily pending final decision of the Engineer's Council. At the present time, there is some doubt that the affair will be staged.

Raymond Murray of the Physics Department spoke on the topic, "Nuclear Power as Applied to Aircraft." He opened his talk by comparing nuclear power with other heat sources. He went on to list the problems that will confront the aircraft industry. These include radiation damage to

Easy as π

In engineering circles, ratios are important.

Take the problem of personal advancement.

If your opportunities are in direct ratio to your ability . . . *it's easy to move up.*

And you'll find those opportunities at TEMCO.

TEMCO's qualified engineers have a chance to go straight to the top on the strength of their own creative skill. There's no waiting to see your designs produced . . . no waiting to have your talents rewarded.

If your present progress doesn't match your potential, a job at TEMCO can make the difference.

And there are openings at TEMCO plants in three Texas communities — at Dallas, Garland and Greenville.

Write:

E. J. Horton, Jr., Engineering Personnel,
TEMCO Aircraft Corporation,
P. O. Box 6191, Dallas, Texas.

TEMCO
AIRCRAFT CORPORATION
DALLAS, TEXAS

Display of airplane models, photographs, and IAS literature set up by the new IAS Student Branch at Stevens Institute of Technology's Engineering Open House.

metals, safety of crew and ground personnel, and means of shielding the reactors. As an example, he pointed out that the present shielding materials, lead and concrete, would of course offer a considerable problem in the design of aircraft.

Professor Murray pointed out that he was discussing only fundamental considerations, as most of the information concerning this subject is classified.

KEITH E. VERBLE, *Secretary*

Oregon State College

Our Faculty Adviser, Harm Buning, addressed 100 engineering students at a joint meeting of the mechanical engineering societies November 1. He talked about his trip to Holland last summer and his work at the National Institute of Aeronautical Research in Amsterdam. In this connection, he mentioned the difficulties of obtaining accurate data in transonic wind-tunnel tests. An interesting comparison on safety-mindedness was made between European and American civil aviation. Professor Buning also reported on his visit to the 1955 Farnborough Air Show in England, illustrating the talk with color slides.

In the business session, the proposed spring field trip was discussed, and every member was urged to submit a technical paper in the forthcoming contest. The two best papers will be presented at the annual IAS Student Conference in Los Angeles.

▶ V. I. Stevens, Assistant Head of the High-Speed Research Division of Ames Aeronautical Laboratory, NACA, spoke on "Heating Problems in Supersonic Flight" at the October 11 meeting.

He discussed the aerodynamic heating problems of glide and ballistic missiles as they leave, and again as they reenter, the earth's atmosphere. He said the greatest heating problems occur as the missile re-enters the earth's atmosphere. The talk was illustrated with slides.

As this was the season's first meeting, the functions of the IAS were explained to new members. Rod Hugelman was elected Secretary.

L. G. MALCOM, *Vice-Chairman*

Polytechnic Institute of Brooklyn

A group of 27 seniors and juniors visited The Glenn L. Martin Company's plant near Baltimore on December 2. Vice-President George S. Trimble, Jr., welcomed us and made a short introductory talk. Then we were introduced to the engineers who were going to be guides for the tour.

First we visited the Engineering Building, where we saw, among other things, a large analog computing machine. The next stop was the Environmental Laboratory where numerous electronic devices were undergoing tests to see if they could withstand the conditions under which they would operate. After leaving the laboratory we were conducted through the manufacturing areas where parts were being made for the P5M Marlin and the Matador guided missile. The route also included parts of the Matador and P5M assembly lines.

After lunch, the group was taken out to the Strawberry Point Structural Test Facility to see the first XP6M-1 SeaMaster. In addition, there was a static test in progress on a B-57. On the way to Strawberry Point, we made a detour to see Martin Airport. Upon our return to the Presentation Room there were discussions by C. J. Koch, Chief Aerodynamicist, and E. J. Tanner, Chief Propulsion Engineer, both of whom answered questions at the conclusion of the talks. A film about the development and launching of the Viking concluded the visit.

▶ Major Josef Singer of the Israeli Air Force, who is studying here for his Doctorate in Aeronautical Engineering, made two talks before the Brooklyn Poly Student Branch on the 1955 Air Show in Farnborough, England, sponsored by the Society of British Aircraft Constructors. In his first talk November 16, Major Singer presented a general description of the air show. On November 30 he continued with a detailed description of the aircraft exhibits, showing slides of photos he had made.

The 1955 SBAC show was divided into three main parts. These were static exhibits, which included about 300 display stands, parked aircraft; and a fly-past that was noted for its display of production versions of prototypes flown at previous shows. The fly-past included several aerobatic displays.

Several new engines were on display in the static exhibits. Among these were the Rolls-Royce Conway and the de Havilland Gyron. Major Singer discussed design details of several aircraft, among them the Hawker Hunter, Folland Gnat, Fairey Delta, Handley-Page Victor, Avro Vulcan, Bristol Britannia, Vickers Valiant, and Short Sperrin.

HOWARD BAUM
Recording Secretary

Stevens Institute of Technology

In November, the seventy-second IAS Student Branch was established at Stevens Institute of Technology, Hoboken, N.J.

Under the Honorary Chairmanship of B. K. Erdoss, MIAS, Professor of Fluid Dynamics and Director of the Fluid Dynamics Laboratory at Stevens, the new Branch initiated its activities by participating in Stevens' Engineering Open House on November 16. The exhibit gave many students the opportunity to familiarize themselves with IAS, and their interest was proved by their enthusiastic support of the new Branch.

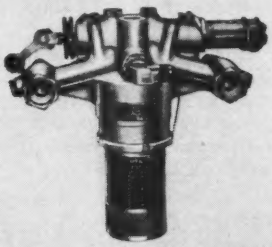
The first Student Chairman is Robert D. Stewart. The Branch under his leadership expects to become a highly active IAS group.

University of Alabama

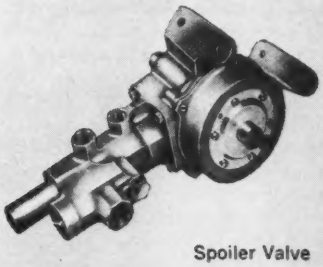
Sixty students were present at the second meeting of the Student Branch October 18. Chairman Charles C. Church presided.

One of the main items of business was a discussion of a proposal from the Atlanta Section of the IAS. This proposal was that the Atlanta Section become a permanent sponsor of the South-

Strut Assembly—
Main Landing Gear Retract



Valve Assembly—Steering Metering



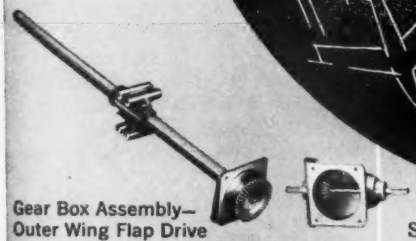
Spoiler Valve

Pneumatic Door Lock

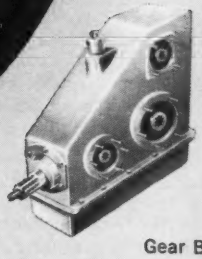
High Heat Treat
Strut Assembly

Sargent

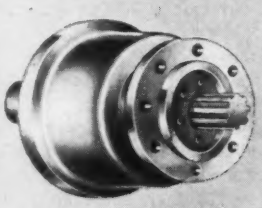
HYDRAULIC,
PNEUMATIC,
AND MECHANICAL
AIRCRAFT
CONTROLS



Gear Box Assembly—
Outer Wing Flap Drive



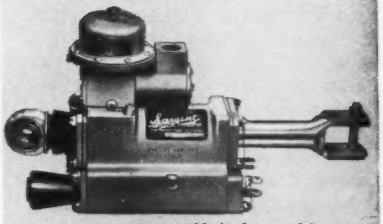
Gear Box



Hydraulic Motor

Sargent Engineering Corporation has designed and manufactured precision equipment for more than 35 years. During the past 18 years alone Sargent has delivered more than 200,000 precision aircraft control units to the country's leading airframe manufacturers.

Write today for your copy of the NEW *illustrated story of Sargent's organization, methods, and manufacturing facilities.*



Unit Assembly—
Surface Power Control

Standard of Excellence Sargent *Since 1920*

"Good will" is the disposition of the pleased customer to return to the place where he has been well treated.
—U.S. Supreme Court

ENGINEERING CORPORATION
2533 EAST 56TH STREET
HUNTINGTON PARK, CALIF.

eastern Regional Conference with the understanding that a host school would preside each year. Various details were fully discussed, resulting in approval of the proposal. Since two schools, The University of Florida and Virginia Polytechnic Institute, were in favor of the arrangement, it was thought that approval by the other schools concerned would follow in due course. It was pointed out that the University of Alabama organized and sponsored the first Southeastern Conference and that all participating schools either had sponsored or had been given the opportunity to sponsor one meeting. It therefore appeared logical that the next meeting should be in Atlanta if the proposal of the Atlanta Branch is adopted.

For the benefit of the many new students attending the meeting, Colgan H. Bryan spoke briefly concerning the purposes and advantages of the IAS Student Branch. He welcomed the new members and urged that they become active in the affairs of the Branch.

The main speaker, William R. Knepshield, was introduced by Chairman Church. Mr. Knepshield spoke on "Dynamic Stability at High Angles of Attack" and used a movie showing research conducted by the NACA at Langley Field to emphasize important points presented. Background for the talk was obtained during the past summer by working at Langley Aeronautical Laboratory. The magnitude and variety of research activities carried on at the Government laboratory were described, and the speaker highly recommended the NACA to those interested in summer employment. Since Mr. Knepshield has worked at other places during previous summers, he was able to compare the various engineering activities engaged in by students employed for the summer. It was suggested that summer employment could be extremely valuable to a student in providing experiences as a complement to classroom work and the usual college environment.

▶ The first meeting of the Student Branch on October 4 was largely a planning session to get acquainted and work up future programs. The new Vice-Chairman, William R. Knepshield, presided and introduced the other officers: Charles C. Church, Chairman; Karl O. W. Ball, Secretary; and Jefferson L. Herring, Treasurer.

The new Faculty Adviser, Edward W. Geller, also was introduced. He is well known to those in the Glider Club. Colgan H. Bryan, who has been Faculty Adviser for a number of years, will continue to be available for assistance.

A discussion of plans for the semester placed considerable emphasis on the need for early work on the Southeastern Regional Student Conference, tentatively scheduled to be held here. Three possible week-end dates in March and April were suggested.

After the business session, Mr. Knepshield spoke on the advantages of membership in the IAS Student Branch. A number of new and prospective members were present. The meeting closed with a movie on *Motorless Flight*.

KARL O. W. BALL, *Secretary*

Orientation

University of Detroit

The Student Branch has successfully completed its first annual orientation program. The idea was suggested by K. E. Smith, Chairman of the Aeronautical Engineering Department. Purpose of the orientation program is to inform the freshman and sophomore engineers interested in aeronautical engineering of the facilities available to them here.

The present presenior aeronautical engineering students felt that they and the men who graduated before them would have had a deeper interest in their pre-engineering work had they received such an orientation. They want to help the young men starting their college careers in engineering as much as possible and to inspire others to obtain a degree in aeronautical engineering.

A departmental assembly was held on October 28 with permission of Dean Freund, Dean of the Engineering College. The assembly was conducted by Robert Prevost, Chairman of the IAS Student Branch, and he was assisted by the entire presenior aeronautical engineering class of 1957, all of whom hold membership in the IAS. Eighty freshmen and sophomores attended the assembly. The orientation began by introducing the students to the organization and its officers. The purpose of the IAS on the campus was explained, and some of the advantages of having membership in the IAS were pointed out. The assembly was divided into eight groups, and each group was taken on a tour through the engineering laboratories and faculty offices.

During the tours the students were able to observe several demonstrations and to ask questions concerning them. The following is a list of some of the exhibits:

(1) A demonstration of the pressure distribution around an airfoil. An airfoil section was mounted in a miniature wind tunnel with a 7 by 10 in. open-throat test section.

(2) A demonstration of the airflow and streamlines around variously shaped objects. A smoke table was used along with a flow table.

(3) An examination of the supersonic wind tunnel and the apparatus used to observe shock waves.

(4) An introduction to the 7 by 10 ft. wind tunnel. Inspection of the six-component balance system, the controls of the wind-tunnel fan, and the pitching and yawing controls.

Of the many highlights of the tour, the large wind tunnel was the most popular. A number of students asked permission to return for a closer look. The orientation was so successful that it was decided at the next meeting to make the program an annual event of the school year. Also, as a result of the program, ten new members were accepted into the IAS.

To continue work along this line, the Student Branch has decided to sponsor a debate for the freshmen and sophomores on the theme "Problems Concerning the Co-op Engineer and Their Solutions."

DAVID C. EWALD, *Secretary*

Rocket Development

University of Illinois

The third meeting of the Student Branch, held in the Mechanical Engineering Building on November 16, drew an attendance of 180 persons. The meeting was cosponsored by the Illinois Rocket Society.

IAS Chairman Jim Piechocki called the meeting to order and extended a welcome to attending members of the Society of Automotive Engineers' Student Branch and the Illinois Rocket Society. The IAS Treasurer's report was presented by Russell Hopps.

H. S. Stillwell, Head of the Aeronautical Engineering Department, then introduced the speaker, Robert Dillaway, Supervisor of Preliminary Design of the Rocketdyne Division of North American Aviation, Inc.

Dr. Dillaway's topic was "Highlights in Large Rocket Engine Development." He said that the major development work was begun at the end of World War II when, with the advent of guided missiles, there was a demand for large liquid rockets. In the early development stages in this country the power plant of the German V-2 rocket was analyzed thoroughly. Dr. Dillaway stated that an engine just begins with a customer's order. This order roughly determines the size of the engine and the placement of the engine in the customer's missile. The rocket engine goes through preliminary design and is then checked by the customer. If the customer still desires the engine, then the development groups analyze, detail-design, and test their components.

Five major groups are now concerned with the engine. The main group is that which deals with the combustion devices. It is concerned with the thrust chamber, nozzle, injectors, manifolds, and the gas generator. Another group

is concerned with the turbopump, which usually comprises one-half the dry weight of the engine. A controls group is concerned with the regulation of chamber pressure, starting sequence systems, etc. The stress group is responsible for the structural safety and life of the engine. This stress work has different considerations from the usual aircraft stress work, for rocket engine lifetimes are measured in seconds and minutes. The final group is the test group, which is concerned with the entire rocket engine system.

Dr. Dillaway closed by saying that rocket engines are getting out of the "Model T" stage and that reliability is now an important consideration.

Two films were shown during the meeting, *Horizons Unlimited* and a film on a turbopump.

ROBERT J. SHANAHAN, *Secretary*

University of Kansas

At a meeting of the Student Branch on November 29, H. M. Gaebe, Chief of Design Operations at Chance Vought Aircraft, Inc., Dallas, Tex., was the speaker. His topic was "Air-Frame Design Problems Peculiar to High-Speed Aircraft."

Mr. Gaebe explained that there are two important problems in high-speed design—configuration and environment. He showed slides illustrating some of the problems arising from increased speed—e.g., greater dynamic pressure, aerodynamic heating, higher landing speeds, the need for reduction of wing thickness, and the need for more effective metals.

In a description of some of these problems, Mr. Gaebe predicted that surface smoothness will become increasingly important because a protuberance may cause a shock wave at supersonic speeds. He explained that, to avoid torsion effects in a sweptback wing, the shear center is located as far aft as possible. To illustrate the effects of high temperature on metals, Mr. Gaebe showed a short NACA movie of a model in a wind tunnel disintegrating because of thermal effects. Some of the possibilities for controlling thermal effects are the use of ceramics, new fuels, and refrigeration.

Mr. Gaebe also gave a brief description of the area-rule or "Coke Bottle" method of reducing the cross section of the fuselage at the wing roots in order to reduce drag at transonic speeds.

▸ R. M. Robbins, Senior Project Engineer of B-47 production at Boeing Aircraft Company, Wichita, Kan., spoke at a meeting of the K.U. Student Branch on November 15. His topic was "Flight Testing the XB-47."

The first test pilot to fly the XB-47, Mr. Robbins told many details of preparing to fly the plane for the first time. He explained that he learned about the different components one at a time.

XLO
EX-CELL-O for PRECISION
Nozzles for JETS
THIS IS ONE
of many Stainless Steel nozzle assemblies for jet engines built by Ex-Cell-O Corporation, one of the world's largest producers of aircraft precision parts.

There's *something of Ex-Cell-O* in practically every plane made in the U.S.A. today.

Illustrated below are typical blades, nozzles, hydraulic actuating assemblies and fuel control assemblies, precision built by Ex-Cell-O Corporation to aircraft builders' rigid specifications.

53

EX-CELL-O CORPORATION DETROIT 32, MICH.

MANUFACTURERS OF PRECISION MACHINE TOOLS • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS
DRILL JIG BUSHINGS • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT

For example, the engine was tested on the ground and aloft in a B-29; and F-80 was used to obtain experience in flying jets; and the tail surfaces were "flown" in a wind tunnel to get the feel of the controls.

The problems encountered in the selection of take-off and landing sites, in determining how much fuel to carry, and in selecting the proper weather conditions were also discussed.

At the close of his talk, Mr. Robbins advised the student engineers to consider carefully their reasons for wanting to be engineers and their goals for the future.

MARJORIE HEARD, *Secretary*

University of Michigan

The meeting of November 16 was called to order by Chairman Robert Lauer. William Liller, Professor of the Astronomy Department, spoke on "Aspects of Modern Astronomy," emphasizing the matter from which the galaxy was formed and means of its detection. Slides were presented showing various nebulas and dust clouds present in our own galaxy, as well as some of our neighboring galaxies.

ROBERT R. JONES, *Secretary*

University of Notre Dame

Chairman Joseph P. Poynton opened a regular meeting of the Student Branch on November 17 in the Student Center. Fifty members were present.

Patrick T. Chiarito of the Lewis Flight Propulsion Laboratory, NACA, Cleveland, spoke on the need for young aeronautical engineers and the role they will play in the rapidly growing aviation industry. He covered the various fields a young engineer could go into, such as propulsion, structures, design, or research.

A movie, *Research for Tomorrow's Aircraft*, presented the objectives of the NACA and showed its personnel at work with various unique facilities. It also included a sequence of flights by missiles, flights by the custom-built research airplanes used to study problems beyond Mach 2, turbojet tests in tanks at simulated altitudes up to 70,000 ft., and many other interesting subjects.

RAYMOND J. MAUREN, *Secretary*

The University of Texas

The Student Branch called a special meeting November 14 to hear Walt Davies deliver a talk on some of the problems encountered in the production of high-speed aircraft. Mr. Davies, Group Armament Engineer for North American Aviation, Inc., Columbus, Ohio, stressed the importance of high-speed fire control in modern aircraft.

Accompanying Mr. Davies was R. J. Thiebert, also from North American Aviation at Columbus. Mr. Thiebert described the general personnel structure of the aircraft industry.

Mr. Davies brought four movies which were shown following the lectures: *Continental Defender*, *Carrier Landings of the AJ-1*, *First Flight of the FJ-4*, and *The NATIV Guided Missile*.

JACK L. REASONER
Corresponding Secretary

West Virginia University

Chairman Richard E. Walters opened the November 16 meeting of the Student Branch by announcing that the scheduled speaker, A. I. Neihouse of Langley Aeronautical Laboratory, NACA, could not be present because his plane had been grounded by bad weather at Charleston, W.Va.

The Chairman then brought forth a two-reel film to substitute for the missing lecturer. Part One, *Aerodynamics: Airflow*, used drawings and wind-tunnel photos to illustrate the airflow around flat plates, cambered plates, and simple airfoils at various angles of attack. The wind-tunnel shots were especially good, indicating clearly the movement of air around the test models.

Part Two, *Forces Acting on an Airfoil*, explained the forces and pressures on flat plates and simple airfoil sections. It also explained how test data are obtained in wind tunnels by manometers and other recording devices. Leon Z. Seltzer, Head of the Aeronautical Engineering Department, pointed out important features as the film unfolded.

RAY HERRING
Corresponding Secretary

MEMBERS ELECTED

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the Review.

Elected to Associate Fellow Grade

Busemann, Adolf, Dr. Ing., Staff Scientist, Langley Lab., NACA

Drake, Robert M., Jr., Ph.D. (ME), Supvr., Turbine Air Design, Devel. Engine Sect., Devel. Dept., AGT Div., General Electric Co.

Seiff, Alvin, B.S., Aero. Research Scientist & Head, Supersonic Free-Flight Wind Tunnel Branch, Ames Aero. Lab., NACA.

Transferred to Associate Fellow Grade

Luckert, Hans J., Ph.D., Design Specialist, Group Leader, General Aerodynamics Group, Canadair, Ltd.

Phillips, Frederick C., B. of Ae.E., Head, Aerodynamics & Prelim. Design Sects., Canadair, Ltd.

Useller, James W., B.Sc., Proj. Engr., Lewis Lab., NACA.

Wheeler, James W., B.S. in E.E., Dir.—Instrument Engrg., Aero. Equipment Div., Sperry Gyroscope Co. Div. Sperry Rand Corp.

Wilkins, Ernst W. C., Ph.D., Sr. Member—Tech. Staff, RAeS; Principal, Aero Consultants & Co. (London).

Elected to MEMBER Grade

Akeroyd, Edward T., B.S., Sr. Loads Engr.—Airframes, McDonnell Aircraft Corp.

Andreasson, Bjorn O., B.S., Sr. Design Engr., Lead Man, Contr. Group, Convair, San Diego, A Div. of General Dynamics Corp.

Arens, M., M.S., Proj. Engr., Head, Engine & Devel. Sect., Curtiss-Wright Corp.

Averitt, Robert A., B.S.E.E., Mgr.—Aviation Systems Engrg., General Electric Co. (Schenectady).

Bennett, James H., Jr., B.S.M.E., Mgr., Electro-Mech. Engrg. Dept., The Glenn L. Martin Co.

Cook, Arthur J., Jr., B.S.M.E., Branch Mgr., Sales Engr., Aero. Engrg. Co., Div. of Garrett Corp.

Delano, J. D., Jr., B.S.M.E., Tech. Engr., Aircraft Performance Evaluation, General Electric Co. (Cincinnati).

Engel, Walter J., B.A. in Chem., Metallurgist-Process Engr., Northrop Aircraft, Inc.

Eskinazi, S., M.S.M.E., Assoc. Prof.—Mech. Engrg., Syracuse Univ.

Forster, Michael C., B.A., Mgr., Operational Design Evaluation Group, Douglas Aircraft Co., Inc. (Santa Monica).

Fossett, William K., B.A. in C.E., Producibility Methods Engr.—Aircraft, Lockheed Aircraft Corp. (Marietta).

Foster, Jack E., B.S., Test Pilot, Sperry Gyroscope Co. Div. Sperry Rand Corp.

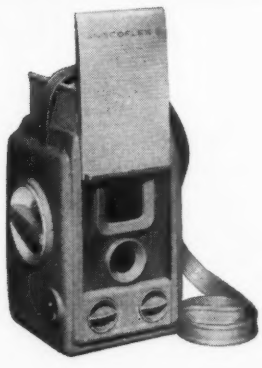
Haefeli, Rudolph C., B.S. in Engrg. (Physics), Sr. Engr., The Glenn L. Martin Co.

Hallet, Raymon W., Jr., B.S.M.E., Power Plant Thermo & Performance Engr., Douglas Aircraft Co., Inc. (El Segundo).

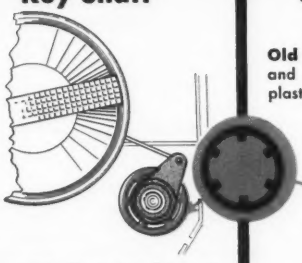
Houser, J. Grover, B.S.A.E., Engr.—Aircraft Design, The Glenn L. Martin Co.

5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera



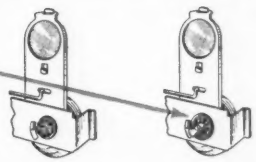
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

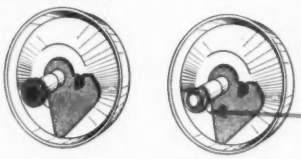
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



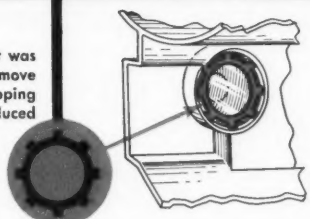
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-topping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

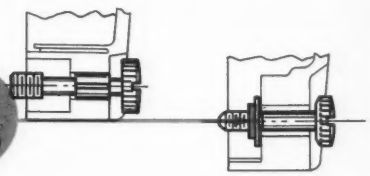


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

Ansco, Binghamton, N. Y., uses the latest technical advances in construction to produce an economical, easy-to-use reflex camera. 5 Waldes Truarc Rings are used in this new design to save material and labor costs, eliminate parts, simplify assembly and reduce rejects.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting . . .Waldes Truarc Grooving Tool!

Send for new catalog supplement

WALDES
TRUARC®
RETAINING RINGS

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N. Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name.....
Title.....
Company.....
Business Address.....
City..... *Zone*..... *State*..... AE028

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

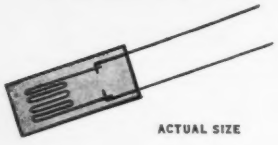
DEPARTMENT OF TECHNOLOGY BUFFALO AND ERIE COUNTY PUBLIC LIBRARY

Airframe Engineers take Notice!

Now measure SURFACE temperatures NOT AMBIENT AIR with high-output, low-cost,

RdF STIKON®

Resistance Thermometer Elements . . .



ACTUAL SIZE

Critical surface temperatures occurring in current high-performance aircraft are easily measured by RdF Stikons. The thinness of the RdF Stikon (.005 to .010 in.) allows its temperature-sensitive grid to become virtually an integral part of the measured surface thereby *eliminating*, for practical purposes, the *influence of ambient air temperature.* With an RdF Stikon you can easily obtain an output voltage *several hundred times higher* than the output of the most sensitive thermocouples.

Write today for Temperature Measurement and Control Brochure T-54

ARCRA ARTHUR L. ROUS ASSOCIATES
733 CONCORD AVENUE
CAMBRIDGE 38, MASS

Hubbart, James E., M.S., Thermodynamic Engr., Lockheed Aircraft Corp. (Burbank).

Kerley, James J., Jr., Sr. Devel. Engr., Air Arms Div., Westinghouse Electric Corp.

Lecarme, Jacques, Tech. Adviser & Test Pilot, SNCASE (Paris).

Lieberman, Norman, B.S.E., Asst. Proj. Engr., North American Aviation, Inc. (Los Angeles).

Lyons, Herbert B., Jr., B.S. in Ae.E., Stress Analyst, Douglas Aircraft Co., Inc. (Long Beach).

Marshall, Peter L., B.A., Proj. Engr., North American Aviation, Inc. (Columbus).

North, David A., M.Ae.E. Proj. Engr., American Airlines, Inc. (Tulsa).

Osder, Stephen S., M.S. in Engrg., Engr.—Flight Control Systems, Sperry Gyroscope Co. Div. Sperry Rand Corp.

Pawson, Arthur M., B.S.M.E., Mgr.—Aircraft Installation & Service Engrg., General Electric Co. (Seattle).

Rau, John M., Jr., S.M., Mgr., Airborne Systems Div., G. M. Giannini & Co., Inc.

Ringo, Edward W., Pres. & Gen. Mgr., Flight Enterprises, Inc.; V-P, Transocean Air Lines.

Rohde, Frederick W., Quality Engr., Mech. Engrg. Div., AGT Div., Westinghouse Electric Corp.

Smith, William C., Asst. Proj. Engr., Sverdrup & Parcel, Inc.

Spelber, Leonard G., B.S., Aerodynamicist, Wind Tunnel Model Design Group, Grumman Aircraft Engineering Corp.

Standahar, Raymond M., M.S.M.E., Propulsion Planning Engr.—New Product Planning, General Electric Co. (Cincinnati).

Townsend, John M., A.A., Aero. Engr., Aircraft Div., Hughes Tool Co.

Van Meerten, H. C., Deputy Dir. & Chief Engr., N. V. Kon Ned. Vlieftuigenfabrik "Fokker."

Verdery, Patricia T., B.A., Liaison Engr.—Airships, Goodyear Aircraft Corp.

Vieth, Frederick D., Application Engr., Airborne Armament Dept., The W. L. Maxson Corp.

Williams, Arthur L., B.S.M.E., B.S.Ae.E., Sr. Struct. Engr., Convair, San Diego, A Div. of General Dynamics Corp.

Williams, Raymond H., B.S.M.E., Mgr., Aviation Div., Dunlop Tire & Rubber Corp.

Willis, Eldrich J., B.S.M.E., Sect. Head, Aviation & Central Engrg. Sects., Devel. Div., Aluminum Co. of America (Cleveland).

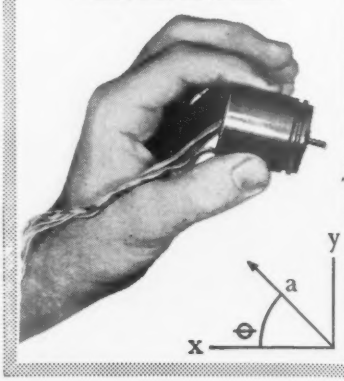
Transferred to MEMBER Grade

Benson, Allen M., B.S. in Ae.E., Aerodynamicist "A," Aerodynamics Group, Ryan Aeronautical Co.

Berger, Richard E., B.S. in Ae.E., Research Engr., North American Aviation, Inc. (Columbus).

TELESYN® 400 CYCLE RESOLVERS

from FORD INSTRUMENT



- **STANDARD RESOLVERS** in Sizes 15 and 23.
- **RESOLVER SYSTEMS** incorporating size 23 resolvers, network box and amplifier.
- **and SPECIALS** designed to the particular application.

Ford Instrument's *Telesyn* Resolvers – precision-built for the extreme efficiency and accuracy of the Company's computers and control systems – are available to meet your *own* quality requirements.

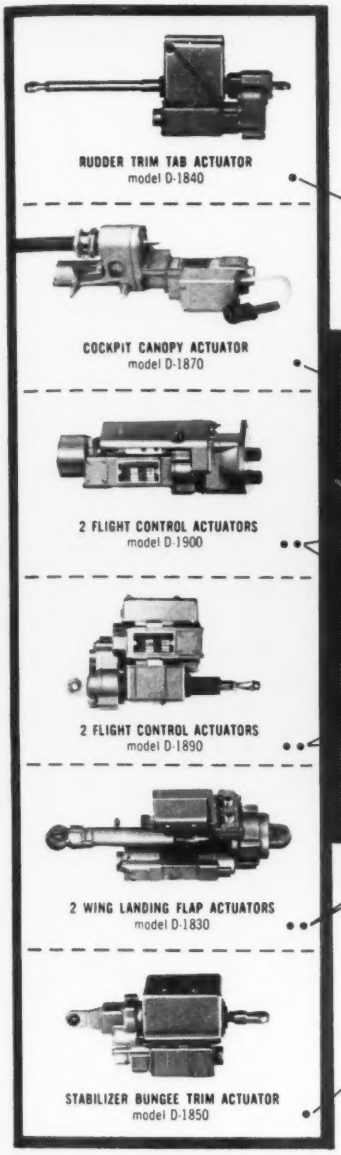
FREE – Fully illustrated data bulletin gives specifications and performance information. Please address Dept. AER

69A

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components

9 HOOVER ACTUATORS
flex the muscles of the Navy's New Fury Jet



North American FJ-4 Fury. Now in production at North American's Columbus, Ohio division for the Navy, this carrier-based, swept-wing jet fighter has a high rate of climb and speed in excess of 690 mph.

Hidden under the skin of North American's new FJ-4 Fury jet are nine custom-built Hoover Electric actuators that provide precise, dependable power and control—for flying the Navy's latest Super Jet.

Exactingly designed—and precisely built—for maximum performance under all conditions—these Hoover-built electric power control units have been an integral contribution to American aircraft development for more than a decade. Aircraft designers, engineers and pilots alike—rely on Hoover dependability—and Hoover has always repaid that confidence with Performance PLUS!

Hoover Electric will design and manufacture special actuators and motors, special gearing and complete power package units for any application—in experimental or production quantities. Write today!

Hoover Electric Motors And Actuators Are Providing Dependable Power And Control For Operating

horizontal stabilizers	camera doors
camera drive	fuel jettison actuator
ram air inlet	cockpit canopy
landing hook	pilot seat actuators
aileron control	hydraulic pump
hot air valve	high pressure air pumps

HELCO

HOOVER ELECTRIC COMPANY

2100 South Stoner Avenue
Los Angeles 25, California
Eastern Representative — Columbus, Ohio

Bollard, Richard J. H., Ph.D. (Aero. Engrg.), Struct. Consultant, James Aviation, Ltd.; Lecturer, Univ. of New Zealand.

Charak, Mason T., M.S. in Ae.E., Aero. Research Scientist, NACA (Washington, D.C.).

Kelso, George C., Engr.—Flight Test, North American Aviation, Inc. (Los Angeles).

La Forge, Sally V., B.S. in M.E., Aero. Engr., Aerodynamics Group, Helicopter Research Dept., Aircraft Div., Hughes Tool Co.

Lays, Edward J., B.S. in Ae.E., Aerodynamics Engr., North American Aviation, Inc. (Columbus).

Moore, John A., M. of Ae.E., Aero. Research Scientist, NACA, Langley AFB.

Nadworny, Henri C., B. of Ae.E., Engrg. Layout Man—Airframe Struct., Fuselage Group, Grumman Aircraft Engineering Corp.

Rains, Dean A., Ph.D. in M.E., Aerodynamics Engr., Compressor Group, Propulsion Research Co.

Ruetenik, J. Ray, Dr. Engr., Research Staff Engr., Massachusetts Institute of Technology.

Sanlorenzo, Ernest A., A.B., Lt. & Staff Engr., USAF, Hq. AEDC (Tullahoma).

Schultz, Donald L., B.S.

Sigoda, Merton A., S.M., 2nd V-P, Man-Sew Corp.

Smetana, Frederick O., M.S. in M.E., Research Assoc., Engrg. Center, Univ. of Southern California.

Steffen, Fred W., B. of Ae.E., Aero. Research Scientist, Lewis Flight Propulsion Lab., NACA.

Stenning, Alan H., Dr. Sc., Asst. Prof., Mech. Engrg. Dept., Massachusetts Institute of Technology.

Weiss, David C., M.S. in Ae.E., Prelim. Design Engr., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Wooten, Guy G., M.S.E., Lt., USN; Naval Aviator & Maint. Officer.

Elected to Associate Member Grade

Maggi, John J., Owner-Tech. Dir., Security Parachute Co.

Pfeiffer, R. James, Executive Dir.—Customer Relations, Fairchild Engine & Airplane Corp.

Elected to Technical Member Grade

Crosson, James G., Asst. Designer, Piasecki Helicopter Corp.

Hilton, Allen E., Test Engr., Northrop Aircraft, Inc.

Howard, Eli P., A.B., Dynamicist, Flutter & Aeroelastic Analysis, Radioplane Co.

Kettering, Charles, Engr.—Electrical Group, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Lagopoulos, Alkis N., Proj. Engr., Engrg. Sect., National Greek Airlines.

White, Eric S., B.M.E., Mech. & Proj. Engr., Winder Aircraft Corp.

Wolfe, Harry W., Jr., Ph.D., Research Chemist, Jackson Lab., E. I. du Pont de Nemours & Co., Inc.

Transferred to Technical Member Grade

Allender, J. Reverdy, B.S. in Ae.E., Aero. Engr.—Flight Test, AFFTC, Edwards AFB.

Amsler, Earle C., Engrg. Asst. "A," Northrop Aircraft, Inc.

Anderson, Frank L., A.A., Electrical Design Engr., Sikorsky Aircraft Co.

Bailey, Earl H., B.S. in Aero., Asst. Prof., Boston Univ.

Beswick, Keith L., B. of Ae.E., Assoc. Engr.—Flight Test, Lockheed Aircraft Corp. (Burbank).

Boulton, Donald, B.S. in Ae.E., Jr. Aerodynamicist, McDonnell Aircraft Corp.

Brown, Woodridge C., B.S., Pfc., U.S. Army; Instructor—Aviation Hydraulics, Army Transportation School, Ft. Eustice.

Cannon, John N., B.S.M.E., Engr.—Aerodynamics, North American Aviation, Inc. (Downey).

Chamberlain, Clarence N., Jr., Major, USAF; Proj. Engr., WADC, Area B, W-P AFB.

Chan, Hugh W., B.S., Graduate Student, Div. of Mech. Engrg., Univ. of California (Berkeley).

Chandler, Robert C., Jr., B. of Ae.E., Assoc. Engr., Aerodynamics Dept., The Glenn L. Martin Co.

Clark, Robert N., B.S., Assoc. Engr.—Aerodynamics, Lockheed Aircraft Corp. (Burbank).

Clune, James G., Jr., Instrumentation Engr., Arnoux Corp.

De Amicis, Salvatore J., B.S. in Ae.E.

Der, James J., B.S., Jr. Engr.—Aerodynamics, North American Aviation, Inc. (Downey).

Dunn, Henry J., Jr., B.S. in Ae.E., Capt., USAF; Struct. Aero. Engr., Officers Mail Sect., Brookley AFB.

Dvorscak, Bernard J., B. of Ae.E., Production Test Pilot, Lockheed Aircraft Corp. (Burbank).

Finch, Earl C., B.S. in Ae.E., Jr. Engr. "B," Boeing Airplane Co.

Fink, James E., B.E., Jr. Engr.—Aerodynamics, North American Aviation, Inc. (Los Angeles).

Goodman, Leonard, B.S. Engrg., Lt., USAF; Aircraft Maint. Officer, 57th Air Div., SAC, Fairchild AFB.

Griffin, Burlin M., B.S. in Ae.E., Assoc. Engr.—Flight Analysis, Lockheed Aircraft Corp. (Burbank).

Hecht, Marvin, B. of Ae.E., Struct. Engr., Bell Aircraft Corp.

Henderson, Richard B., B.S. in Ae.E., Engr., Electronics Servo Units, Sanders Associates.

Hilker, Donald H., B.S.M.E., Major, USAF; Chief, Management & Resources Div., Directorate of Procurement, ARDC, W-P AFB.

Jackson, Thomas J., Liaison Engr., McDonnell Aircraft Corp.

Jaroszewski, Edward C., Test Engr., Curtiss-Wright Corp.

King, Edward W., B.S.A.E., Test Engr., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Kunz, Richard E., B.S. in Aero., 2nd Lt., USAF; Student Navigator, Harlingen AFB.

Lyon, Frank J., B.S. & BAE, Lt., USAF; Proj. Engr., WADC, WCLSS-1, W-P AFB.

Mauser, Gary B., B. of Ae.E., Aero dynamicist, Grumman Aircraft Engineering Corp.

McAlister, Michael J., B.S. in Aero., Data Analyst—Flight Test, McDonnell Aircraft Corp.

McDill, Paul L., B.S., Jr. Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

McIlroy, William, Ph.D., Principal Aerodynamicist, Republic Aviation Corp.

Menard, Joseph A., B.S. in Ae.E., 2nd Lt., USAF; Flying Training Student, Bainbridge AB.

Michel, F. Curtis, B.S., Jr. Engr., Firestone Tire & Rubber Co.

Miller, Richmond L., Jr., Capt., USAF; Proj. Engr., Hq. AFFTC, Edwards AFB.

Mital, John A., B.S.

O'Keefe, Joseph K., B. of Ae.E., Lt., USAF; Engrg. Maint. Officer, Walker AFB.

Romer, Eugene M., M.S. in Ae.E., 1st Lt., USAF; Proj. Engr., Control Requirements Sect., Flight Control Lab., WADC, W-P AFB.

Schapker, Richard L., B.S. in Ae.E., Advanced Compressor Design Engr., General Electric Co. (Evendale).

Schubert, James J., B.S., Jr. Engr. "B," Boeing Airplane Co.

Sleeper, Robert K., B.S., Jr. Engr., Chance Vought Aircraft, Inc.

Smith, Ronald C., B. of Ae.E., Aero. Research Intern, Ames Aero. Lab., NACA.

Stinnett, Glen W., B.S. in Ae.E., Aero. Research Intern, Ames Aero. Lab., NACA.

Straddeck, John T., Jr., Designer, Chance Vought Aircraft, Inc.

Suran, Richard E., B.S. in Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Taylor, Lawrence W., Jr., B.S. in Ae.E., 2nd Lt., USAF; Flight Test Engr., Edwards AFB.

Tirman, C. J., B.S. in M.E., Mech. Engr., Hughes Tool Co.

Van Putten, Donald J., Jr. Engr.—Design, North American Aviation, Inc. (Columbus).

Wheeler, John T., B.S. in Ae.E., Aerodynamics Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

Yang, Hsun-Tiao, Ph.D., Research Fellow, California Institute of Technology.

Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering world-wide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

A key to the abbreviations used for titles of periodicals and report series is published semiannually, in the January and July issues.

The AERONAUTICAL ENGINEERING INDEX, published since 1947, provides an annual cumulation of the materials reviewed in this section.

THE IAS LIBRARY

Publications reviewed in this section are maintained by the Library for use by the IAS Membership. They are *not* for sale but are made available through the facilities of the Library.

LENDING SERVICES: Institute members, both Individual and Corporate, may borrow periodicals, reports, and books for a period of 2 weeks, excluding time in transit. Excepted are certain reference books and those IAS publications that may be purchased.

PHOTOCOPY SERVICES: The Library is equipped to provide, as a service, positive photocopies of certain materials in its collections. Rates on request.

For detailed information about these and other services, write to:

John J. Glennon, Librarian
Institute of the
Aeronautical Sciences, Inc.
2 East 64 Street
New York 21, New York

PERIODICALS & REPORTS..... 102
INTERNATIONAL AERONAUTICAL ABSTRACTS. 107
BOOKS..... 147

Subject Index to Periodicals & Reports

Acoustics, Sound, and Noise..... 102
Aerodynamics
- Boundary Layer..... 102
- Control Surfaces..... 102
- Fluid Mechanics & Aerodynamic Theory..... 102
- Internal Flow..... 102
- Stability & Control..... 104
- Wings & Airfoils..... 104

Aeroelasticity..... 106
Aeronautics, General..... 106
Air Transportation..... 106
Airplane Design..... 106
- Air Conditioning & Pressurization.. 106
- Operation & Performance..... 106

Airports..... 106
- Heliports..... 106

Computers..... 106
Electronics
- Amplifiers..... 124
- Antennas..... 124
- Circuits & Components..... 124
- Communications..... 124
- Crystals..... 124
- Dielectrics..... 124
- Electronic Controls..... 124
- Electronic Tubes..... 124
- Magnetic Devices..... 124
- Measurements & Testing..... 124
- Navigation Aids..... 124
- Networks..... 124
- Oscillators & Signal Generators.... 126
- Semiconductors..... 126
- Transmission Lines..... 126
- Wave Propagation..... 126

Equipment
- Electric..... 126
- Hydraulic & Pneumatic..... 128

Fuels & Lubricants..... 128
Gliders..... 128
Ice Formation & Prevention..... 128
Instruments
- Automatic Control..... 128
- Flight Instruments..... 128
- Flow Measuring Devices..... 128
- Gyroscopes..... 128
- Pressure Measuring Devices..... 128
- Recording Devices..... 128
- Stress & Strain Measuring Devices.. 130
- Temperature Measuring Devices.... 130

Machine Elements
- Bearings..... 130
- Gears & Cams..... 130
- Transmission, Clutches, & Drives.... 130

Materials..... 130
- Corrosion & Protective Coatings... 130
- Metals & Alloys..... 130
- Metals & Alloys, Nonferrous..... 132
- Nonmetallic Materials..... 132
- Testing..... 132

Mathematics..... 134
Meteorology..... 134
Missiles..... 136
Navigation..... 136
Photography..... 136
Physics..... 136
Power Plants
- Atomic..... 136
- Jet & Turbine..... 136
- Ram-Jet & Pulse-Jet..... 136
- Rocket..... 136

Production
- Metalworking..... 138
- Tooling..... 138
- Welding..... 138

Propellers..... 140
Reference Works..... 140
Refueling in Flight..... 140
Rotating Wing Aircraft..... 140
Safety..... 140
Space Travel..... 140
Structures..... 140
- Beams & Columns..... 140
- Connections..... 140
- Cylinders & Shells..... 142
- Elasticity & Plasticity..... 142
- Plates..... 142
- Testing..... 143
- Thermal Stress..... 143
- Weight Analysis & Control..... 143
- Wings..... 143

Thermodynamics..... 143
- Combustion..... 143
- Heat Transfer..... 143

Vertical Take-Off Aircraft..... 143
Water-Borne Aircraft..... 143
Wind Tunnels & Research Facilities... 143

Acoustics, Sound, and Noise

Background Information on Sound Abatement by the Aircraft Industry. *AIAA Release No. 55-43*, June 24, 1955. 14 pp.

Étude du Bruit des Turbo-Réacteurs. M. Kobrynski and P. Liénard. *La Recherche Aéronautique*, July-Aug., 1955, pp. 57–59. In French. Study of the turbojet noise problem, with operational data on acoustic emission and sound level distributions.

A Theoretical Analysis of the Field of a Random Noise Source Above an Infinite Plane. Peter A. Franken. *U.S., NACA TN 3537*, Nov., 1955. 20 pp. Use of a finite-band-width receiver for atmospheric acoustic measurements in the far field for the special case of a perfectly reflecting plane, with an extension to include the case of a plane of arbitrary impedance.

Aerodynamics

Boundary Layer

An Analysis of Aerodynamic Data on Blowing Over Trailing Edge Flaps for Increasing Lift. Appendix I. Appendix II—Blowing Coefficients for Compressible Slot Flows. J. Williams, *Gt. Brit., ARC CP 209* (Sept., 1954), 1955. 33 pp. 25 refs. BIS, New York. $0.90. Evaluation of wind-tunnel boundary-layer-control test results.

Boundary-Layer Measurements in Hypersonic Flow. F. K. Hill. *J. Aero. Sci.* Jan., 1956, pp. 35–42. 19 refs. NAVORD-supported experimental calculations at Johns Hopkins U. of the boundary-layer formation, heat transfer, and skin-friction coefficient at Mach Numbers of 8.25 and 9.0 on the wall of a conical nozzle in the presence of a favorable pressure gradient and several rates of heat transfer.

Calculations for Mass Transfer at a Plane Surface Along Which Flow Occurs, at High Partial Pressure Gradients (Berechnung des Stoffüberganges an einer ebenen, längsangeströmten Oberfläche bei Grossem Teildruckgefalle). E. Eckert and V. Lieblein. (*Forschung Gebiete Ing., Berlin, Mitteil.*, No. 2, 1949, pp. 33–42.) *Gt. Brit., RAE Lib. Transl. 540*, Sept., 1955. 19 pp. 10 refs. Analysis for the formation of a laminar boundary layer under the assumption that constant temperature prevails inside the boundary layer and that the molecular weights of diffusing substance and carrier gas are practically the same.

Compressible Laminar Boundary Layer and Heat Transfer for Unsteady Motions of a Flat Plate. Simon Ostrach. *U.S., NACA TN 3569*, Nov., 1955. 26 pp.

Couche Limite le Long d'une Plaque Plane en Écoulement Subsonique; Étude Expérimentale. Gérard Gontier. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 19, 20. Experimental investigation of the influence of compressibility on velocity profiles, the shifting thickness, and the thickness of the movement in the boundary layer along a plate in subsonic flow.

The Development of Turbulent Boundary Layers. D. A. Spence. *J. Aero. Sci.*, Jan., 1956, pp. 3–15. 21 refs. Investigation based on Schubauer-Klebanoff, Ludwieg-Tillmann, and Townsend experiments and using the power law $u/U = (y/\delta)^n$ related to equations of momentum, skin friction, and form parameters and to the velocity profiles and the eddy structure of the boundary layer.

Effects of Pressure Gradient and Heat Transfer on the Stability of the Compressible Laminar Boundary Layer. Norman M. Shapiro. *J. Aero. Sci.*, Jan., 1956, pp. 81–83.

Laminar Free Convection from a Vertical Plate with Uniform Surface Heat Flux. Appendix—Comparison of Local Nusselt Numbers for Uniform Wall Temperature and Uniform Surface Heat Transfer. E. M. Sparrow and J. L. Gregg. *ASME Diamond Jubilee Semi-Annual Meeting, Boston, June 19–23, 1955, Paper 55-SA-4.* 5 pp.

Mass Transfer Cooling in a Laminar Boundary Layer with Constant Fluid Properties. J. P. Hartnett and E. R. G. Eckert. **Appendix—Solution of the Momentum Equation for Plane Stagnation Flow Under Conditions of Blowing at the Wall Surface.** J. P. Hartnett, E. R. G. Eckert, and R. L. Sampson. *U. Minn. Inst. Tech. Dept. Mech. Eng. TR 4*, Oct., 1955. 50 pp. 15 refs. Solution for the prediction of heat transfer, skin friction, and required coolant flows for transpiration-cooled surfaces.

An Approximate Solution of the Laminar Boundary Layer on a Flat Plate with Uniform Suction. S. J. Peerless and D. B. Spalding. *J. RAeS*, Oct., 1955, pp. 697, 698. Method using "similar" profiles and the wall shear stress, taking into account the variation of suction velocity but neglecting the momentum integral.

A Simple Approximate Method for Calculating the Laminar Boundary Layer with Suction. E. Truckenbrodt. *Braunschweig Tech. Hochschule Inst. Strömungsmech., Rep. 55/6a*, May 21, 1955. 62 pp. 13 refs. USAF-sponsored development of the method applied to cases of two-dimensional and axially symmetrical flows with an arbitrary distribution of suction velocity along the surface, and with comparisons to solutions from other approximations.

Turbulent Boundary Layer Control by Ramps or Wedges. A. V. Stephens and G. A. Collins. *Australia, Aero. Res. Comm. Rep. ACA-55*, May, 1955. 19 pp.

Control Surfaces

Jet Flap. II. I. M. Davidson. (*RAeS Paper*, Oct. 20, 1955). *The Engr.*, Nov. 4, 1955, pp. 655–657. 12 refs. Abridged. Review of NGTE powered-lift investigations on the large Fowler-flap-like behavior of jet-flapped airfoils based on an aerodynamic resynthesis of the lifting and propulsive means, taking into account the supercirculation phenomena.

Theoretical and Experimental Investigations on Delta-Wings with Flaps. E. Truckenbrodt and K. H. Gronau. *Braunschweig Tech. Hochschule Inst. Strömungsmech. Rep. 55/12a*, June 22, 1955. 45 pp.

Fluid Mechanics & Aerodynamic Theory

Détermination d'un Écoulement Compressible Subsonique à Partir d'un Écoulement Incompressible. P. Bévierre. *La Recherche Aéronautique*, July-Aug., 1955, pp. 3–5. In French. Application of an approximation law of compressibility to the determination of subsonic flows about a profile from incompressible flow characteristics using methods based on transformations of a flow function and of the speed potential.

Calcul Approché de la Résistance à l'Avancement en Transsonique d'un Profil Symétrique à la Portance Nulle. P. Bévierre. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 15–18. In French. Approximate calculation based on the determination of the sonic point of the resistance of a symmetrical profile of zero lift to movement in transonic flow.

The Effect of Support Interference on the Base Pressure of a Body of Revolution at High Reynolds Numbers. Kenneth R. Sivier and Seymour M. Bogdonoff. *Princeton U. Dept. Aero. Eng. Rep. 332 (AFOSR TN 55-301)*, Oct., 1955. 41 pp. 21 refs. Theoretical and experimental investigation of viscous effects in supersonic flow.

The Forces on the General Slender Body of Elliptic Cross Section in Supersonic Flow. H. Portnoy. *J. Aero. Sci.*, Jan., 1956, pp. 91, 92.

On Variational Principles for Real Fluids. Paul Lieber, Olaf Anderson, and K. S. Wan. *Rensselaer Polytech. Inst. Dept. Geol. OSR TN 55-370*, Oct., 1955. 35 pp. Theoretical development of a lifting theory for bodies of revolution not governed by the Kutta theory.

Sur la Résistance d'un Corps de Révolution en Mouvement Accéléré ou Décéléré. A. von Baranoff. *La Recherche Aéronautique*, May-June, 1955, pp. 11–14. In French. Study based on linear theory of the resistance of a body of revolution in uniformly accelerated or decelerated motion when crossing the sound barrier.

Analytical Treatment of Two-Dimensional Supersonic Flow. II—Flow with Weak Shocks. J. J. Mahony. *Australia, ARL Rep. A.94*, Apr., 1955. 33 pp. Approximate solution of the shock-wave problem for a steady plane flow of a perfect gas based on an extension to interaction regions of the Friedrichs method neglecting any entropy variations produced by weak shocks, with an evaluation of the applicability of the homentropic theory and provisions for error estimation.

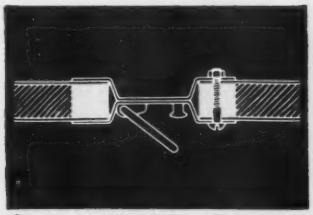
Interaction of a Shock Wave with a Thermal Boundary Layer. Wayland C. Griffith. *J. Aero. Sci.*, Jan., 1956, pp. 16–22, 66. Investigation using an experimental technique of sliding a hot plate into the shock tube before the shock occurs to develop a linearized theory based on the Lighthill method of obtaining the shock shape and flow field for cases of a shock sufficiently strong and the heating small enough for the shock to extend clear to the surface.

Internal Flow

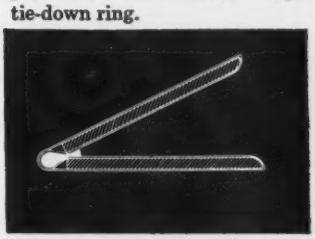
Charts of Boundary-Layer Mass Flow and Momentum for Inlet Performance Analysis Mach Number Range, 0.2 to 5.0. Appendix A. Appendix B—Application of Charts to Arbitrary-Shaped Inlets. Appendix C—Application to Boundary-Layer Inlet-Pressure Recovery. Paul C. Simon

How many riveting and welding operations can you eliminate with

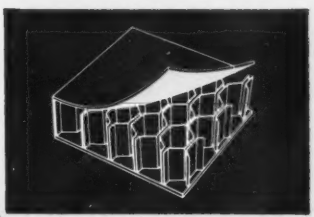
SOLVENT-FREE



Section of Bondolite* floor panel (*T. M. Goodyear Aircraft Corporation) with inserted cargo tie-down ring.



Wing flap section made from Bondolite. Bend is reinforced with Epon Adhesive VI.



Bondolite honeycomb construction. Epon Adhesive VI bonds aluminum skin to central aluminum honeycomb.

EPON® ADHESIVES?

New Epon adhesives are being specified to replace expensive riveting and welding in an ever-increasing variety of aircraft applications. Because they contain no solvents, Epon adhesives permit immediate assembly of metal-to-metal bonded parts. Contact pressure alone is all that is required to form sound bonds. Surfaces before bonding need not be machine-finished and glue lines need not be uniform. Air-relief drilling is never needed.

For your specific needs, three standard formulations are:

- **EPON ADHESIVE VI: General purpose, high-strength adhesive. Cures at room temperature or slightly above.**
- **EPON ADHESIVE VIII: High strength, capable of withstanding moderately high service temperatures. Cures in 90 minutes at 200°F.**
- **EPON ADHESIVE 422: A special formulation in tape form for service at temperatures up to 500°F.**

Epon adhesives have been used successfully in bonding metal, plastics, rubber and wood for helicopter rotor blades, honeycomb wing sections, jet fuel tanks, radar antennae, structural joints and floor panels. Can Epon adhesives solve an assembly problem for you? Write us about your problem and we'll send full technical information and samples.

(Epon resins are the epoxy polymers made exclusively by Shell Chemical Corporation)

SHELL CHEMICAL CORPORATION

CHEMICAL PARTNER OF INDUSTRY AND AGRICULTURE

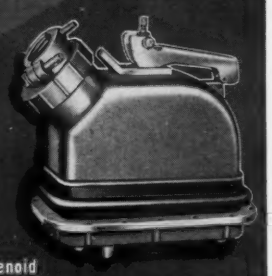
380 Madison Avenue, New York 17, New York

Atlanta • Boston • Chicago • Cleveland • Detroit • Houston • Los Angeles • Newark • New York • San Francisco • St. Louis

IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited • Montreal • Toronto • Vancouver

40th YEAR

Cannon quality
in missile
launching connectors
means safety



GMA–Solenoid or Manual Release. 41 to 140 Contacts. Coaxials Available.

GMJ–Skid Away Release. 18 Size 14 Contacts.

GMD–Skid Away Release. 22 or 50 Size 14 Contacts.

Performance of missile launching connectors cannot be "hit or miss." It must be right! That's where Cannon's reputation for quality and design experience can help you . . . with the most complete and most reliable line available.

Write TODAY for GMI Bulletin.

CANNON PLUGS

CANNON ELECTRIC CO.
3209 Humboldt Street
Los Angeles 31, Calif.

Please Refer to Dept. No. 105

and Kenneth L. Kowalski. *U.S., NACA TN 3583*, Nov., 1955. 32 pp.

Compressibility Effects on Secondary Flows. H. G. Loos. *J. Aero. Sci.*, Jan., 1956, pp. 76–80. USAF-sponsored investigation at the CIT Jet Propulsion Center generalizing the Hawthorne computational method for problems of the secondary vorticity applied to cascades approached by a flow with a boundary layer developed along an insulated wall and with a Prandtl Number equal to unity.

A Flow Instability Following Shock Reflection from a Flared End of a Duct. George Rudinger and Lowell M. Somers. *Jet Propulsion*, Oct., 1955, pp. 541–544. USAF-ONR-Army-sponsored investigation under Project SQUID.

An Investigation on Fully Developed Turbulent Flows in a Curve Channel. Salamon Eskinazi and Hsuan Yeh. *J. Aero. Sci.*, Jan., 1956, pp. 23–34, 75. 13 refs. ONR-sponsored measurements at Johns Hopkins U. in a high-speed wind tunnel of the influence of the channel curvature between circular, concentric walls.

Application Numérique d'un Calcul d'Amortissement Aérodynamique des Vibrations d'Aubes de Compresseurs. E.-A. Eichelbrenner. *La Recherche Aéronautique*, July-Aug., 1955, pp. 7–14. In French. Estimate of aerodynamic damping of compressor blade vibrations for the case of a blade grid inclined at 45°.

Calcul d'une Grille d'Aubes pour une Distribution de Nombres de Mach Subsoniques Donée en Fonction du Potentiel. Robert Legendre. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 3–9. In French. Calculation of a blade grid for a distribution of subsonic Mach Numbers given as a function of the potential.

On the Role of Reynolds Stresses in Stability Theory. J. T. Stuart. *J. Aero. Sci.*, Jan., 1956, pp. 86–88. Theoretical analysis of the Pai calculations on the stability of two-dimensional parallel flows related to periodic disturbances of finite magnitude in terms of contradictions of the Meksyn-Stuart investigation indicating the unstable character of pressure flows for finite and infinitesimal disturbances.

A Survey of Unclassified Axial-Flow-Compressor Literature. Howard Z. Herzig and Arthur G. Hansen. *U.S., NACA RM E55H11*, Nov. 8, 1955. 88 pp. 253 refs. Review of theoretical and experimental flow and design studies of: airfoils, cascades, stationary and rotating blade rows, stators, and rotors; single-stage and multistage compressor performance, characteristics, parameters, velocity diagrams, boundary-layer effects, testing techniques, and instrumentation; effects of streamline curvature and radial variation of circulation, time-unsteady and viscous flows, three-dimensional and secondary flows, compressibility, Mach Number, and end losses.

Approximate Calculations of Laminar Jets (Supplementary Note). Jun-ichi Okabe. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, July, 1955, pp. 23–27. Error analysis for the case of the plane jet.

The Atomization of Liquids. II. H. A. Troesch. (*ETH, Zurich, Thesis No. 2266*, 1954.) *Engr. Dig.*, Sept., 1955, pp. 436–438. Analysis of centrifuging and velocity atomizer designs and of the characteristic conditions of liquid-jet breakup.

The Effect of Ambient Pressure Oscillations on the Disintegration and Dispersion of a Liquid Jet. C. C. Miesse. *Jet Propulsion*, Oct., 1955, pp. 525–530, 534. USAF-sponsored investigation.

Stability & Control

Détermination des Caractéristiques de Vol d'un Avion en Subsonique Élevé a Partir d'Essais en Soufflerie sur Demi-Maquette. L. Cabot and J. Crouzet. *La Recherche Aéronautique*, May-June, 1955, pp. 3–10. In French. Determination of transonic flight characteristics of an airplane beginning with tests in a high-speed wind tunnel on a half model to measure the longitudinal and transversal stability parameters.

Wings & Airfoils

A Comparison of the Spanwise Loading Calculated by Various Methods with Experimental Loadings Obtained on a 45° Sweptback Wing of Aspect Ratio 8.02 at a Reynolds Number of 4.0×10^6. William C. Schneider. (*U.S., NACA RM L51G30*, 1952.) *U.S., NACA Rep. 1208*, 1954. 11 pp. 14 refs.

The Effect of Reynolds Number on the Stalling Characteristics and Pressure Distributions of Four Moderately Thin Airfoil Sections. George B. McCullough. *U.S., NACA TN 3524*, Nov., 1955. 24 pp.

Flight Investigation at Mach Numbers from 0.6 to 1.7 to Determine Drag and Base Pressures on a Blunt-Trailing-Edge Airfoil and Drag of Diamond and Circular-Arc Airfoils at Zero Lift. John D. Morrow and Ellis Katz. (*U.S., NACA RM L50E19a*, 1950.) *U.S., NACA TN 3548*, Nov., 1955. 19 pp.

The Pressure Distribution Due to Incidence on a Slender Elliptic Half-Cone. C. R. Taylor. *J. RAeS*, Oct., 1955, pp. 694, 695.

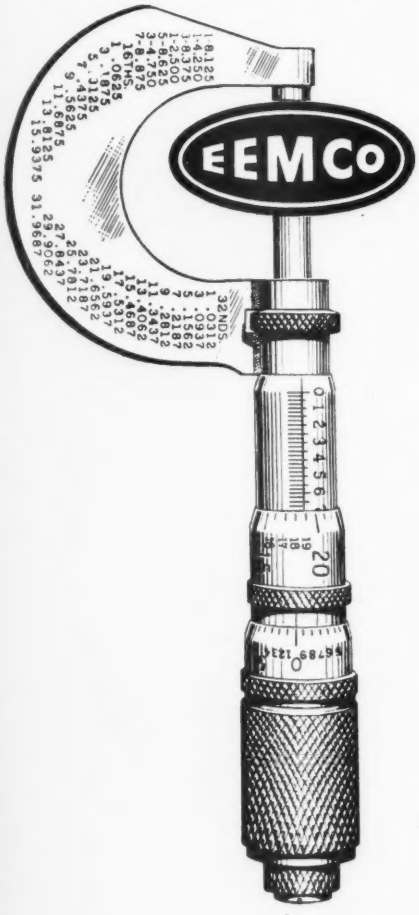
The Calculation of the Wave Drag of an Arbitrary Slender Body by Means of an Electrical Analogy Tank. P. J. Pocock. *Can. Aero. J.*, Nov., 1955, pp. 168–177. 15 refs.

The Lift of a Blowing Wing in a Parallel Stream. D. A. Spence. *J. Aero. Sci.*, Jan., 1956, pp. 92–94. Application of Hembold downwash equations to the case of lift induced on a thin uncambered wing at zero incidence with a thin jet of M momentum flux issuing at a small downward angle from the trailing edge.

Summary of Results Obtained by Transonic-Bump Method on Effects of Plan Form and Thickness on Lift and Drag Characteristics of Wings at Transonic Speeds. Edward C. Polhamus. (*U.S., NACA RM L51H30*, 1951.) *U.S., NACA TN 3469*, Nov., 1955. 33 pp. 30 refs.

Some Effects of Viscosity on Wing-Body Interference at $M = 1.9$. T. R. Rhees and W. P. Crenshaw. *J. Aero. Sci.*, Jan., 1956, pp. 43–48. 11 refs. Results of experiments in the U. Mich. Intermittent-Flow Supersonic Wind Tunnel on a flat rectangular wing-cylindrical body combination with a laminar boundary layer compared with those for the turbulent case on the same body and the predictions of the NACA linearized inviscid theory.

Since 1942



Fourteen years ago **EEMCO** started in a small way. Today it is one of the nation's principal designers and producers of special motors and linear and rotary actuators for aircraft and pilotless missiles.

This forefront place has been achieved because, continually since 1942, **EEMCO** has specialized exclusively in manufacturing these precision components. It has done nothing else!

EEMCO's leading position has been consistently maintained through outstanding service rendered to every customer. **EEMCO** units are used by a majority of the airframe and related manufacturers in the aircraft industry who appreciate **EEMCO** high-quality standards, dependable cost-control methods, and on-time deliveries.

Design and production specialists at **EEMCO** continue to provide designs and prototype models of motors and actuators. These, notably, are in the desirable light-weight, high-output ratios so vital to modern jet aircraft and pilotless missiles. And **EEMCO** produces them in quantity for approved Army, Navy and Air Force models and for most late-design commercial airliners

Designers and producers of motors, linear and rotary actuators

Electrical Engineering and Manufacturing Corp.

4612 West Jefferson Boulevard
Los Angeles 16, California
Telephone REpublic 3-0151

Vortex Interference on Slender Airplanes. Appendix A. Appendix B—Evaluation of the Real Part of a Complex Square Root. Alvin H. Sacks. *U.S., NACA TN 3525*, Nov., 1955. 19 pp. Formulas for the forces and moments except drag due to vortex interference on slender wing-body-tail combinations of general cross section in terms of the positions and strengths of the shed vortices.

Aeroelasticity

Étude de l'Amortissement des Vibrations en Vol par Percussions sur les Surfaces Portantes. G. Coupry, R. Valid, and G. Piazzoli. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 37–42. In French. Flight measurements using spectrographic techniques of oscillation damping by percussion on lifting surfaces taking into account nonstationary aerodynamic motions and characteristic parameters to determine structural responses.

Étude des Vibrations Aéroélastiques des Gouvernes en Subsonique Élevé. A.-G. Meller and A. Berton. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 27–35. In French. Experimental study of aeroelastic vibration controls for the high subsonic range, taking into account the effects of wind-tunnel walls.

Justification d'une Approximation des Forces Aérodynamiques Vibratoires en Écoulement Subsonique Tridimensionnel. J. Legras. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 21–26. In French. Applicability of an approximation method to calculate the vibrational aerodynamic forces in three-dimensional subsonic flow.

Méthode d'Analyse Graphique de la Résultante de Deux Vibrations Sinusoidales Amorties. H. Loiseau and R. Dat. *La Recherche Aéronautique*, July-Aug., 1955, pp. 43–49. In French. A rapid graphic method to analyze periodic phenomena resulting from the superposition of two damped sinusoidal vibrations of different harmonic periods in the determination of each of the frequencies as used for the study of damping of aircraft or dynamic models.

Méthode Pratique de Détermination de la Courbe d'Évolution Théorique du Flottement de Gouverne a un Degré de Liberté. C. Béatrix. *La Recherche Aéronautique*, July-Aug., 1955, pp. 51–55. In French. Practical method to determine the theoretical evolutionary flutter curve for the control and damping of oscillations of one degree of freedom at transonic and supersonic velocities.

A Note on the Transverse Vibration of a Tube Containing Flowing Fluid. George Handelman. *Carnegie Inst. Tech. TR 2 (OSR TN 55-50)*, Feb. 1, 1955. 9 pp.

On Second-Order Non-Linear Oscillations. F. V. Atkinson. *Pacific J. Math.* Suppl. I, 1955, pp. 643–647.

Simulateur pour l'Étude en Laboratoire de la Réponse d'une Structure à une Excitation par une ou Plusieurs Impulsions de Formes Variables. P. Mathon. *La Recherche Aéronautique*, July-Aug., 1955, pp. 39–42. In French. Laboratory apparatus to study response of dynamic structural systems of one or several degrees of freedom and to determine optimum variable impulse simulation for flight testing.

System Mode Shapes in the Flutter of Compressor Blade Rows. Frank Lane. *J. Aero. Sci.*, Jan., 1956, pp. 54–66. USAF-sponsored development at NYU of an analytical method to determine the flutter-inception point in predicting the critical velocity or rotational speed under the assumption of infinite rotor inertia or constant rotor velocity.

Systématisation du Calcul des Vibrations Propres d'une Structure Quelconque Libre ou Partiellement Maintenue par un Bati Fixe à Partir de Coefficients d'Influence. D. Clerc and R. Kappus. *La Recherche Aéronautique*, July-Aug., 1955, pp. 31–38. In French. Systematized vibrational analysis beginning with the influence coefficients of proper frequency modes of a free or partially supported fixed-frame structure.

Vibrations of Elastic Systems Under Initial Stress. George H. Handelman. *Carnegie Inst. Tech. TR 4 (OSR TR 55-28)*, Sept., 1955. 10 pp. Investigation featuring the analysis of the effects of high rotational speeds on beam-like structures, the attachment of rigid masses, and the presence of flowing fluids.

Turbulence Encountered by Comet I Aircraft. Appendix I—Method of Translating Acceleration Into Gust Speed. J. R. Heath-Smith. *Gt. Brit. RAE Rep. Struc. 179*, May, 1955. 26 pp., folded tables. BOAC acceleration operational records of gusts encountered en route, with a description of flight apparatus and instrumentation.

Aeronautics, General

The Application of Air Survey to the Economic Development of a Country. T. D. Weatherhead. *J. RAeS*, Oct., 1955, pp. 682–689.

Current Trends in Research and Procurement in the U. S. Today. I—Selected List of Currently Active and Recently Completed Manufacturing Methods Research Projects (Air Materiel Command). II—Currently Active Research Projects in United States Engineering Colleges. *Aero Dig.*, Oct., 1955, pp. 66 (10 ff.) Survey data broken down by types of projects and by institutions based on AMC, Wright-Patterson AFB, and NYU Eng. Res. Council reports.

Air Transportation

Cooperation in Air Transport; New Medium-Range Airliners. *Interavia*, Oct., 1955, pp. 749–781, cutaway drawings. Partial contents: Thoughts on Strasbourg; The First European Civil Aviation Conference: A Challenge to Europe, L. H. Slotemaker. Cooperation, Willem Deswarte. Turbine Air Transportation One Step Over the Threshold; A Critical Review of Papers Presented at the Seattle Meeting of the Institute of the Aeronautical Sciences, August 8–10, 1955, Maurice A. Garbell. New Aircraft for Short and Medium Stages: Comet 4—Caravelle—Viscount 800—Electra—Friendship—Accountant—HD.32/321—Herald—Convair 440.

The Evolution of Air Mail Rate Making. Gilbert L. Gifford. *J. Air Law & Commerce*, Summer, 1955, pp. 298–342. 49 refs.

Operating and Flight-Planning Techniques for the Viscount. R. H. Chadwick. *J. Inst. Navigation*, Oct., 1955, pp. 331–343. BEA airline-route experience in terms of network requirements of maximum operational pay load, efficiency, and reliability.

Airplane Design

A British Approach to the Area Rule and Transonic Design Considerations. W. T. Lord. *Flight*, Nov. 18, 1955, pp. 769–771. Review of RAE development of design parameters.

Design Analysis of the Handley Page Herald. R. A. Cole. *Aero Dig.*, Nov., 1955, pp. 46–50, cutaway drawing.

The Influence of Basic Airplane Parameters on the Selection of Airborne Systems. R. P. Buschmann. *Aero Dig.*, Oct., 1955, pp. 22–27. Analytical design method to obtain stated objectives in terms of performance, costs, and other defined requirements.

The Olympus Story: The 9,140 lb. s.t. Bristol Olympus B.01. 1 Turbojet, First of the Olympus Series of Twin-Spool Engines Now Rated at Over 11,000 lb. Thrust. *The Aeroplane*, Nov. 4, 1955, pp. 700–713, cutaway drawings.

Air Conditioning & Pressurization

Fatigue of Aircraft Pressure Cabins. Percy B. Walker. (*IAS-RAeS Fifth Internatl. Aero. Conf., Los Angeles, June 20–24, 1955, Preprint 562.*) *Gt. Brit., RAE Rep. Struc. 188*, Sept., 1955. 33 pp. Analysis of the general stress pattern in a pressurized cabin and applied loading cases, with a description of RAE test apparatus and problems of research techniques.

Operation & Performance

Simplified Method for Predicting Take-Off Performance of Propellered Aircraft. Ken S. Coward. *Aero Dig.*, Nov., 1955, pp. 40, 42, 44.

Airports

The Effect of Gusts on Aircraft When Landing. C. S. Durst. *J. Inst. Navigation*, Oct., 1955, pp. 354–357. Evaluation of problems in terms of airport conditions.

The Usability of Airfields in Gusty Winds. J. Wadsworth. *J. Inst. Navigation*, Oct., 1955, pp. 49–353.

Heliports

Planning for Suburban Heliports. Fred M. Glass. *J. Air Law & Commerce*, Summer, 1955, pp. 271–282.

Computers

Analog Measurement and Conversion to Digits. Taylor C. Fletcher and Norman C. Walker. *ISA J.*, Sept., 1955, pp. 341–345. 86 refs. Basic principles, design, and potentialities of voltage converter systems, with a comprehensive bibliography; applications.

(*Continued on page 124*)

INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

Selected and prepared by the IAS Staff from currently released material received in the IAS Library. This research is supported by the Air Force Office of Scientific Research of the Air Research and Development Command. Address inquiries concerning this literature to the IAS Library.

PUBLISHED MONTHLY BY THE AERONAUTICAL ENGINEERING REVIEW

Official Publication of the Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

Volume 1, Number 2 February, 1956

ACOUSTICS, SOUND, AND NOISE

SOUND PROPAGATION INTO THE SHADOW ZONE IN A TEMPERATURE-STRATIFIED ATMOSPHERE ABOVE A PLANE BOUNDARY. Appendix A---APPROXIMATION OF A SLOWLY VARYING MEDIUM. Appendix B---APPROXIMATION TO WAVE EQUATION. Appendix C---SIMPLIFICATION OF EIGENVALUE EQUATION. Appendix D---TEMPERATURE DISTRIBUTION IN A RECTANGULAR ENCLOSURE. D.C. Pridmore-Brown and Uno Ingard. US, NACA TN 3494, Oct., 1955. 57 pp. 11 refs. Theoretical and experimental investigation of the sound field about a point source over a plane boundary in the presence of a vertical temperature gradient using geometrical ray acoustics to derive the ray paths and the intensity distribution about the source located in a uniformly stratified medium, with measurements at varying frequencies of reflecting and absorbing boundaries of the sound distribution in a two-dimensional laboratory chamber with a large temperature gradient.

AERODYNAMICS

Boundary Layer & Thermaerodynamics

BOUNDARY LAYER CONTROL BY POROUS SUCTION. H.G. Lew and R.D. Mathieu. Penn. State U. Dept. Aero. Eng. TR 3, June, 1954. 117 pp. 280 refs. USAF-sponsored review of the literature covering theoretical investigations of means to reduce pressure or form and skin-friction drag, including fundamental equations, exact asymptotic and similar solutions, and momentum and approximate methods for the incompressible and compressible cases; methods of control cover: special airfoil design to keep the position of minimum pressure extremely far back; single or multiple slots to maintain the laminar flow of the boundary layer delaying separation; and continuous boundary-layer suction through a porous surface to effect laminar flow.

THE CRITICAL STUDY OF A BOUNDARY CONDITION ON PRANDTL'S BOUNDARY LAYER THEORY AND ITS APPLICATIONS. Sin-I Cheng. Princeton U. Dept. Aero. Eng. Rep. 329, Sept., 1955. 36 pp. USAF-supported investigation of high-speed flows to study possibilities of developing the fundamental physical concept of similitude or qualitative experimental data used in the Prandtl theory in order to formulate analytically the x-wise expansion parameter determined from the leading-edge boundary condition in terms of the particular requirements of the ordinary subsonic and supersonic steady boundary-layer problems and of the steady hypersonic and unsteady cases of a thin body in a uniform stream, with deductions of series expansions for different types of inflow.

FLIGHT MEASUREMENTS OF AERODYNAMIC HEATING AND BOUNDARY LAYER TRANSITION ON THE VIKING 10 NOSE CONE. R.B. Snodgrass. Jet Propulsion, Dec., 1955, pp. 701--706. 14 refs. Measurements of supersonic convective heat-transfer coefficients at 1.20--5.28 Mach and 5.6×10^4--10.45×10^6 Reynolds Numbers correlating test results on the state of the boundary layer with the Van Driest condition for complete stability of the laminar boundary layer; calculations include graphical plots of measured wall temperature to local stream temperature against local Mach Number for turbulent, transition, and laminar flows, with the analysis based on the principal assumptions of infinite heat conduction through the skin of the Viking nose and zero along it, of validity for the MIT conical flow tables, and the applicability of atmospheric temperature, pressure, and density as summarized by the Rocket Panel.

HEAT TRANSFER FROM A FLAT PLATE THROUGH A TURBULENT BOUNDARY LAYER.

D.R. Davies. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 326--337. Calculation of the similarity solution based on the Townsend experimental results, with a derivation of an expression for the mean rate of heat transfer from a section of the plate providing for a small temperature difference between the plate and the free stream; application of the results, based on the assumption of the proportion between heat and momentum diffusivity, compared to the theoretical results of the Elias mean velocity profile measurements for flow over a smooth heated flat plate as extended to the case of flow under shearing stress.

TRANSITION STUDIES AND SKIN-FRICTION MEASUREMENTS ON AN INSULATED FLAT PLATE AT A MACH NUMBER OF 5.8. R.H. Korkegi. J. Aero. Sci., Feb., 1956, pp. 97--107, 192. 37 refs. USAF-Army-sponsored investigation in the GALCIT 5 x 5 in. Hypersonic Wind Tunnel using a phosphorescent lacquer technique for transition detection, results of which compare favorably with those of total head rake measurements along the plate surface and of pitot boundary-layer surveys, indicating a laminar boundary layer at Reynolds Numbers of at least 5×10^6 and a transverse contamination caused by the turbulent boundary layer on the tunnel side wall originating far downstream of the flat plate leading edge at Reynolds Numbers of $1.5\text{--}2 \times 10^6$ and spreading at a uniform angle of 5 1/2 degree compared to 9 1/2 degree in low speed flow; includes the results of analysis of the effects of two-dimensional and local disturbances, using the air-injection technique as a means of hastening transition in the boundary layer at Reynolds Numbers as low as 10^6, a fully developed turbulence not obtainable at Reynolds Numbers much below 2×10^6 regardless of the amount of air injected, with a qualitative discussion of these results indicating the possibility of greater stability of the laminar boundary layer in hypersonic flow than at lower speeds; calculations from direct skin-friction measurements and using the floating element technique over a range of Reynolds Numbers, based on distance from flat plate leading edge, between $10^6\text{--}4 \times 10^6$, indicating a laminar boundary layer, over the complete range without artificial tripping.

Control Surfaces

AN EXPERIMENTAL INTRODUCTION TO THE JET FLAP. N.A. Dimmock. Gt. Brit., NGTE Rep. R.175, July, 1955. 68 pp. Test results on two-dimensional airfoils of a 12.5 per cent thick elliptical cross section with a narrow full span jet slot at the trailing edge and the jet deflections set at 90° and 31.4° in terms of the hypothesis that the measured thrust is greater under appropriate conditions than the reaction component from the deflected jet, with an investigation of the system losses including those due to Reynolds Number and jet entrainment effects, and with measurements at zero incidence of the influence of ground proximity on the lift and center of lift of the 31.4° model to develop a tentative empirical expression for the pitching moment coefficient.

Fluid Mechanics & Aerodynamic Theory

AN EXPERIMENTAL STUDY OF ONE-DIMENSIONAL REFRACTION OF A RAREFACTION WAVE AT A CONTACT SURFACE. I.J. Billington. U. Toronto Inst. Aerophys. Rep. 32 (OSR-TN-55-334), June, 1955. 116 pp. 12 refs. Investigation of the rarefaction wave generated by the bursting diaphragm in a shock tube and its interaction with air-helium and air-argon interfaces over a large range of incident rarefaction-wave strength, taking into account higher pressure and lower velocity, and using a piezoelectric gauge to measure pressure changes, hot wires for stagnation temperature and mass flow changes through the interaction, and the drum camera technique to measure the velocity of the moving contact front.

FLUID DYNAMIC EFFECTS AT SPEEDS FROM M=11 to 15. S.M. Bogdonoff and A.G. Hammitt. (IAS 23rd Annual Meeting, New York, Jan. 24--27, 1955, Preprint 525.) J. Aero. Sci., Feb., 1956, pp. 108--116, 145. USAF-sponsored investigation in a helium hypersonic blowdown type wind tunnel at the Princeton U. Gas Dynamics Lab. of the phenomena of viscous and inviscid interactional effects over the fore part of a flat plate, two wedges, and a column using schlieren and interferometric techniques, with calculations of the pressure distributions and analytical results indicating extremely high pressures up to ten times the values predicted by inviscid theories for the region close to the nose of the body, and with an estimate of the differences between predictions and numerical values obtained in terms of the influence of leading edge thickness and the associated problem of the highly curved shock wave; includes a comparative review of theoretical and experimental studies of the boundary-layer and external flow relations, with a brief description of techniques, conceptual models, and apparatus used.

LEADING EDGE EFFECTS ON THE FLOW OVER A FLAT PLATE AT HYPERSONIC SPEEDS. A. G. Hammitt, I.E. Vas, and S.M. Bogdonoff. Princeton U. Dept. Aero. Eng. Rep. 326, Sept., 1955. 31 pp. 16 refs. USAF-supported investigation including optical studies over a range of leading-edge thicknesses covering a ratio of 350 to 1 and pressure distribution data for the thicker end of the range in the helium hypersonic wind tunnel, with a description of the experimental techniques and equipment and a detailed analysis of the test results of shock shape using a series of solid models at Mach Number of about 12.7 calculated on the basis of conditions at the leading edge with the stagnation pressures between 800 and 1,400 psi and of the pressure distribution over the flat plate for relatively thick leading edges.

PROGRESS IN RESEARCH ON HIGH SPEED FLOW; A SURVEY OF ADVANCES AND PROBLEMS IN THE STUDY OF HIGH SPEED FLOW. I---NORMAL SUPERSONIC FLOW. II---TRANSONIC FLOW. Maurice Holt. Aircraft Eng., Nov., Dec., 1955, pp. 371--373, 392--395. 15 refs. Analysis of basic principles, relative merits, and potentialities of investigational approaches of the method of characteristics and linearized theory with its equation of motion taking the form of the wave equation governing first order disturbances to fields of uniform flow as applied to the cases of flow past cones, circular cylinders, yawed bodies of revolution, thin wings or slender bodies at small angles of incidence, and flow through ducts of varying cross-section; evaluation of the problems of the transonic region to arrive at the required special approximation to the linearized equation for such cases as flow past an airfoil or through a channel using the von Karman similarity parameter and the Tricomi equation.

ON THE SONIC DRAG OF A SLENDER BODY. J.W. Miles. J. Aero. Sci., Feb., 1956, pp. 146--154. 12 refs. An evaluation of the wave drag in a flow over a body in a sonic free stream, divided into subsonic and supersonic regions, through a matching of linearized theory with the asymptotic Guderley and Yoshihara solutions for the sonic line, indicating a reliable approximation of the head drag on any slender body of revolution terminating in a sharp shoulder, with the results potentially extended to free-stream Mach Numbers slightly different than unity, and for the case of a smooth body terminating either in a cylindrical section or a pointed end, being dependent only on the cross-sectional distribution in a simple form and not restricted to a body of revolution; results further indicate that the sonic drag of a sharp shouldered body is of the same order of magnitude as its supersonic drag, whereas the sonic drag of a smooth body is only a small fraction of its supersonic drag.

SECOND-ORDER METHODS IN INVISCID SUPERSONIC THEORY. J. Fell and D.C.M. Leslie. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 257--265. Application of a particular integral of the second-order perturbation equation to the general three-dimensional case, with a comparison of results to those of the Van Dyke investigation on the axisymmetric problem.

SU UN METODO GRAFICO PER RISOLVERE LE EQUAZIONI DEL MOTO NELLA TEORIA IMPULSIVA SEMPLICE DI UN'ELICA IN UN FLUIDO PERFETTO COMPRESSIBILE, AERIFORME (ON A GRAPHICAL METHOD FOR THE SOLUTION OF THE EQUATIONS OF MOTION IN THE SIMPLE AXIAL-MOMENTUM THEORY FOR A PERFECT GAS). Umberto Nobile. L'Aerotecnica (Rome), Aug., 1955, pp. 163--170. In Italian. Includes a derivation of formulas to solve the subsonic flow equations for the case of a small loading, taking into account the influence of the Mach Number of the free flow on the Mach Numbers immediately behind and in front of the actuator disk in a compressible inviscid fluid and indicating the effect of the power absorbed by the disk.

VISCOUS FLOW ALONG A FLAT PLATE MOVING AT HIGH SUPERSONIC SPEEDS. Y.H. Kuo. J. Aero. Sci., Feb., 1955, pp. 125--136. 16 refs. CIT Jet Propulsion Center investigation, as an extension of the Lighthill studies, of the basic problem to derive solutions for the viscous and inviscid fields and the interaction between these two fields of flow, as the leading edge shock with the boundary layer, to produce an increase of the shear stress on the plate first, then reaching a maximum asymptotically to follow the classical law of friction by increasing the distance from the leading edge of the plate; analysis includes an indication that by the distortion of coordinates the boundary-layer and the Friedrichs simple-wave theories may be combined to obtain a complete representation of the velocity and pressure fields, a derivation of an expression for the induced pressure on the plate correct to the second order, and a deduction of the asymptotic shock curve and skin-friction coefficient, with a further indication that at high Mach Numbers the pressure formula reduces to the same form as that on the wedge airfoil for both the viscous and the inviscid fields obtaining solutions dependent on a parameter corresponding to that of Tsien's hypersonic similarity law.

Internal Flow

APPLICATION OF THE LIGHTHILL MATHEMATICAL METHOD TO THE TEST CASCADE DESIGN. A.W. Wright and E. Szomanski. Australia, ARL Mech. Eng. Note 201, June, 1955. 45 pp. Use of the velocity distribution on the unit circle to obtain the corresponding cascade shape and an airfoil design with predetermined surface-pressure gradients by a series of conformal transformations as based on complex variable theory, and as a modification and extension of the Lighthill approach; analysis includes calculations of the pitch-chord ratio and stagger angle, with a detailed evaluation of results.

COMPRESSIBLE SUBSONIC FLOW IN TWO-DIMENSIONAL CHANNELS. II---THE APPLICATION OF THE THEORY TO PROBLEMS OF CHANNEL FLOW. L.C. Woods. Aero. Quart., Nov., 1955, pp. 254--276. NPL Aero. Div. development of a method of solution based on conformal mapping for the case of flow between curved walls or between walls subjected continuously to varying pressures as applied to the problem of setting of "streamline" walls about a symmetrical airfoil placed in the center of the channel, with a deduction of the position of the walls from the experimentally determined position of a constant pressure wall, taking into account the wake of the airfoil; analysis includes illustrative calculations of the flow about a circular cylinder having a diameter of about half the tunnel height for straight and constant pressure walls, with data on the solid blockage.

INDUCTION SYSTEM SELECTION. Appendix ---ANALYTICAL COMPARISON OF ISENTROPIC INTERNAL AND EXTERNAL COMPRESSION INLETS. Harry Drell and T.A. Sedgwick. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 594. 15 pp. Members, $0.50; nonmembers, $0.85. Analysis of inlet flow and drag characteristics optimized for a given design flight Mach Number in terms of typical engine performance at high speeds in the tropopause taking into account the entire propulsive force balance and installation producing the maximum propulsive thrust and range; the total pressure recovery plotted for the external case as a function of cowl lip angle under the assumption of four degrees of thickness at the cowl lip and distributed equally about the direction of the flow, with the computations for the isentropic supersonic compression based on further assumptions of a curved external compression surface followed by a normal shock wave and for the internal case derived from the free-stream Mach Number to a 1.3 Mach Number also followed by a normal shock, and with the subsonic diffuser total pressure losses for both cases analyzed in terms of the formula:

$$\frac{H_3}{H_2} = 1 - 0.13 \left(\frac{q_2}{H_2}\right);$$

includes cowl drag predictions from two-dimensional theory modified by an arbitrary correction factor.

INVESTIGATION OF SURFACE VELOCITY AND PRESSURE DISTRIBUTION ALONG CASCADE PROFILES. I---VELOCITY DISTRIBUTION AT A HIGHLY CAMBERED SINGLE PROFILE. II---A METHOD FOR VELOCITY CALCULATION AT THIN CAMBERED CASCADE PROFILES. III---VELOCITY DISTRIBUTION ON A RADIAL CASCADE. IV---FINAL REPORT. H. Krüger. Max-Planck-Inst. für Strömungsforschung (Göttingen) TR, 1953--1955. 32, 42(?), 43, 52 pp. Includes a review and a comparison of theoretical and experimental results and details of the test equipment, with a tabulation of form parameters taking into account form deviations between the circular arc profiles and iteratively given wings and the analytical results given in numerical and partly graphical form for cascades in general potential flow for the problems of: the total calculation of the circular cascade and its geometry; stagger and profile thickness correction; inflow relations; and blade velocities and circulations; analysis includes calculations to provide solutions of the integral equations for circular arc profiles of different camber, with tables to determine velocity for given normal components; and practical applications with mechanical quadratures for such cases as semicircles in parallel flow.

MOUVEMENT OSCILLATOIRE AVEC VISCOSITÉ ET INERTIE. Appendix I---APPLICATION DE LA MÉTHODE DES SURFACES DE SÉPARATION À L'ÉTUDE DE L'ÉCOULEMENT D'UN FLUIDE INCOMPRESSIBLE ET VISQUEUX À TRAVERS UN TUBE CIRCULAIRE SOUS UNE CHARGE CONSTANTE. Claire Clarion. France, Min. de l'Air PST 303, 1955. 76 pp. 23 refs. In French. Theoretical and experimental study, based on the Navier equations of revolutionary flows, of the free oscillatory motion of a column of liquid in a U-shaped duct; includes measurements of the cycle and oscillation damping and of the profile of displacements, using the method of surface separation as extended to the analysis of the case of flow of an incompressible and viscous fluid through a circular tube subjected to a constant load.

OBLICZANIE STRAT PRZEPŁYWU PRZEZ PALISADĘ ŁOPATEK TURBINOWYCH (CALCULATIONS OF THE PRESSURE-LOSS OF FLOW THROUGH TURBINE BLADE CASCADES). Robert Szewalski. Arch. Budowy Maszyn (Warsaw), No. 3, 1955, pp. 265--273. In Polish, with summaries in English and Russian. Study based on the Bernouilli equation under the assumption of constant density of the fluid and taking into account the loss of energy to obtain measurements of individual stream-lines by the difference of pressure on both sides of the channel between two blades, with the coefficient for the whole channel, under the further simplifying assumption of uniform distribution of velocity in front of the channel, representing the relation of the loss of energy per unit of mass of the fluid to its kinetic energy in the conditions of inviscid fluid motion without losses.

ROTATIONAL FLOW THROUGH CASCADES. I---THE COMPONENTS OF VORTICITY. W.R. Hawthorne. II---THE CIRCULATION ABOUT THE CASCADE. W.R. Hawthorne and W.D. Armstrong. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 266--292. 11 refs. Theoretical and experimental investigation of the flow of a fluid with a nonuniform velocity passing through a cascade of turbine or compressor blades to determine the nature of the components of vorticity in the direction of flow, with two of the components lying in the stagnation streamline leaving the blade and the third one distributed in the stream; analysis considers the distributed secondary circulation as due to the curving of the flow in a bend or passage between the blades, in accordance with the Squire-Winter calculations; the trailing shed circulation as due to the change in circulation along the blade found in the flow of a uniform fluid about a wing of finite span; and the trailing filament circulation as due to the stretching of the vortex filaments carried with the flow between the upper and lower stagnation streamlines in the wake of each blade; application to isolated airfoils and cascades based on the assumption that the secondary flow is confined to the rectangular passages between and extending downstream from the blades, with an estimation of the strength of the trailing vortex sheet separating each blade passage, and with verifying data of pressure distribution on a cascade of impulse turbine blades for the predicted variation of lift and circulation.

HEAT TRANSFER TO AN INCOMPRESSIBLE TURBULENT BOUNDARY LAYER AND ESTIMATION OF HEAT-TRANSFER COEFFICIENTS AT

SUPERSONIC NOZZLE THROATS. Mervin Sibulkin. J. Aero. Sci., Feb., 1956, pp. 162--172. 12 refs. USAF-Army-sponsored investigation at the CIT Jet Propulsion Lab., deriving an approximate solution for the heat transfer to the turbulent layer with arbitrary free-stream-velocity and surface-temperature distributions, based on the simultaneous solution of the boundary-layer momentum and energy integral equations and on several simplifying assumptions, particularly that the boundary-layer velocity and total temperature profiles and the skin-friction co-efficient are independent of pressure gradient, with calculations for the cases of two-dimensional and axisymmetric flows; development of a throat approximation involving only the nozzle supply conditions, throat opening, and throat radius of curvature to estimate rapidly the maximum rate of heat transfer occurring near the throat of a supersonic nozzle; application of the results, using the quasi-incompressible procedure, provides heat-transfer coefficients, based on both the momentum and energy equations, of between 0 and 15 per cent lower than values resulting from the use of the momentum equation alone and the heat-transfer coefficients including the effects of variable wall temperature of between 0 and 15 per cent lower than the values obtained under the assumption of a constant wall temperature.

THRUST CHARACTERISTICS OF UNDEREXPANDED NOZZLES. F. P. Durham. Jet Propulsion, Dec., 1955, pp. 696--700. NOTS-sponsored investigation at the U. of Colo. with the theoretical analysis based on simplifying assumptions of a steady, adiabatic, and one-dimensional flow of an ideal gas having constant specific heat, except that the thrust is corrected for three-dimensional exit effects by a divergence factor, neglecting the boundary layer except as a source of friction, using two basic de Laval designs of 1/2 in. throat diameter and 15° exit semiangle cone, one having a smooth surface of 20 microin. and the other a rough surface of 300 microin. subjected to high-pressure low-temperature air used as the working medium with a nozzle inlet test pressure at 33 atmospheres to obtain a maximum nozzle thrust from an area ratio less than that required for complete expansion and from a nozzle having an area ratio of little more than half of that required for complete expansion to obtain thrust equal to that for complete expansion, with nozzle losses expressed in terms of velocity coefficients, taking into account the possible use of tables of thermodynamic properties of the working fluid for numerical solutions and such an equation of state for analytical solutions as that of Beattie-Bridgeman; includes experimental results verifying predictions.

Performance

OPTIMAL TRAJECTORIES IN THE HORIZONTAL PLANE. I, II. Hermann Behrbohm. SAAB TN 33, 34, 1955. 24, 22 pp. 10 refs. Investigations of brachistochrone flight paths in three dimensions, specifically treating the problems, through a derivation of necessary conditions for the extremals in the form of the Euler differential equations, of determining a zero-yaw optimal-time flight path to take into account weight changes, the Mach effect on aerodynamic drag, and the effect of speed on thrust in order that (1) a body from given magnitude and azimuth of the velocity vector in the starting point reaches a given speed and azimuth in the end point of the path, and that (2) a body of constant weight from a given speed and azimuth angle in the starting point in optimal time reaches a point moving along a known path in a known manner; analysis includes calculations for the problems of time-optimal and fuel-optimal flight paths having prescribed endpoints and of the highest and most distant climb in a given time, with provisions for machine computation of data from the related systems of the Euler equations.

Stability & Control

THE DERIVATION AND USE OF AERODYNAMIC TRANSFER FUNCTIONS OF AIRFRAMES. I---AERODYNAMIC TRANSFER FUNCTIONS OF AIRFRAMES. II---OPEN LOOP RESPONSES OF AIRFRAMES. III---CLOSED LOOP PERFORMANCE OF AUTO-PILOTS. F. R. J. Spearman. J. RAeS, Nov., 1955, pp. 743--761. Analysis of the aerodynamic characteristics in terms of the relationships between input and output for each of the three separate planes of motion of roll, pitch, and yaw under the assumption of no cross-coupling between planes and linear aerodynamics, taking into account other assumptions related to conventional airframes with fixed wings and rear controls, to obtain relatively simple approximate algebraic transfer functions of the relationships between the control surface deflection as the input and any airframe motion as the output; application of the derived functions to autopilot block diagram design expressing component performance of actuators, instruments, and electrical networks in transfer-function form used in the synthesis of autopilot closed-loop design, with equations of autopilot roll stabilization and steering systems, and with provisions for analog computations.

STABILISATION OF THE AEROPLANE IN SYMMETRIC FLIGHT AT ZERO OR VERY SMALL AIR SPEEDS. Appendix I. Appendix II---GYROSCOPIC YAWING COUPLE DUE TO PITCHING OF THE AIRCRAFT. W. S. Coleman. Aero. Quart., Nov., 1955, pp. 295--328. Investigation of the problem of the possible use of jet thrust as a source of lift, by such means as the deflection of force from the normal propulsion axis under conditions of hovering flight and flight at speeds for which aerodynamic damping becomes insignificant, in terms of the requirements of longitudinal-symmetric motion with the automatic control force responsive to the angular displacement and velocity in pitch; analysis includes a solution in a closed analytical form of

stability needs in a gust or in a succession of disturbances and a step-by-step integrational procedure for the general case of unsteady motion; discussion of illustrative examples indicating the characteristics of automatic control and conditions necessary to obtain stability under different flight circumstances.

Wings & Airfoils

DOWNWASH BEHIND WINGS AT SUPERSONIC SPEEDS: A SIMPLIFIED METHOD FOR CALCULATION AND EXPERIMENTAL RESULTS FOR WINGS WITH SMALL ASPECT RATIO. Willie Jacobs. Sweden, Flygtekniska Försöksanstalten, FFA Medd. 61, 1955. 52 pp. 16 refs. Theoretical and experimental investigation based on the assumption of a system consisting of a single bounded vortex and of the free vortices lying in the horizontal plane; approximation of the circulation distribution along the span by a polynom, with graphical calculation of the downwash, and with a comparison of the method to exact measurements on straight, trapezoidal, and delta-wings with small aspect ratio at 1.4 and 1.8 Mach Numbers.

EQUATIONS FOR THE LOADING, SECTION PITCHING-MOMENT COEFFICIENT AND CENTER-OF-PRESSURE DISTRIBUTIONS ON TRIANGULAR WINGS HAVING SUPERSONIC LEADING AND TRAILING EDGES FOR VARIOUS BASIC CAMBER DISTRIBUTIONS. J.H. Kainer. J. Aero. Sci., Feb., 1956, pp. 137--145. Application of the linearized supersonic flow theory to obtain generalized equations in closed form and in the form of design charts for rapid estimation of the subject material valid for configurations of supersonic leading and trailing edges, with quantitative graphical data derived for constant, linear, parabolic, and cubic camber distributions to account for the presence of body interference, geometric warp, and aeroelastic effects similar to the effects of twist in terms of the analytical results for the pressures, potentials, section normal-force coefficients, section pitching-moment coefficients, and section centers-of-pressure.

PREDICTION OF DOWNWASH AT VARIOUS ANGLES OF ATTACK FOR ARBITRARY TAIL LOCATIONS J.L. Decker. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 615. 15 pp. 10 refs. Members, $0.50; nonmembers, $0.85. Development of a semi-empirical graphical procedure based on simple theoretical relationships to determine during preliminary design studies the downwash in the symmetry plane at the height of the tip vortices at the longitudinal station of the tail, to correct this value for tail heights above the vortices, and to evaluate the effect of tail span by relating the average downwash at the tail height above the vortices; includes a calculation of the flow direction in the plane of symmetry at the longitudinal stations at the wing trailing edge along the chord line and at distances far downstream of the wing, with the downwash velocity due only to the fully rolled up tip vortices.

PROPRIÉTÉS CALCULÉES D'AILES EN DELTA ÉCHANCRÉ OU NON; CALCUL PAR ANALOGIES ÉLECTRIQUES. L. Malavard, R. Duquenne, M. Enselme, and C. Grandjean. France, ONERA NT 25, 1955. 61 pp. 17 refs. In French. Rheoelectric analogical method used to study the influence of the three basic parameters of sweep, curvature, and taper on the effect of incidence of 30 delta-type or delta-derived wings, with values for the global coefficient of lift and thrust center and of circulation and pressure distributions for each of the plan forms; analysis includes calculations for the solution of the curvature of the wing tips, the singularity at the apex, and the configuration of flow paths.

SUMMARY OF RESULTS OBTAINED BY TRANSONIC-BUMP METHOD ON EFFECTS OF PLAN FORM AND THICKNESS ON LIFT AND DRAG CHARACTERISTICS OF WINGS AT TRANSONIC SPEED E. C. Polhamus. (US, NACA RM L51H30, 1951.) US, NACA TN 3469, Nov., 1955. 33 pp. 30 refs. Langley high-speed 7 x 10 ft. wind-tunnel transonic investigational data using an adapted NACA wing-flow technique at Reynolds Numbers of less than 1×10^6 on a semi-span model mounted in the high-velocity flow field generated over the curved surface of a bump located on the tunnel floor; includes comparative analyses of the results of various experiments on different types of wings and the verification of the applicability of available subsonic, transonic, and supersonic theories.

LIFT AND LIFT DISTRIBUTION OF WINGS IN COMBINATION WITH SLENDER BODIES OF REVOLUTION. H.J. Luckert. (CAI 1st Annual Gen. Meeting, Toronto, May 20, 1955, Preprint.) Can. Aero. J., Dec., 1955, pp. 205--217. 12 refs. Development of a practical analogical method covering the whole range of wing aspect ratios and ratios of body width to wing span and particularly applied to the cases of a wing aerodynamically untwisted along the span, the zero lift lines of the profiles having the same angle of attack as the fuselage axix and of a constant wing setting along the span having a zero angle of attack for the fuselage with calculations of the distribution for a unit angle for both cases; analysis includes comparative evaluation of the calculating techniques of: Lennertz and Multhopp, for the case of an unswept wing in subsonic flow based on the lifting-line theory and applicable to high aspect and small ratios of body width to wing span; Spreiter, for delta wings of low aspect ratio in mid-wing combinations; and Low and Stone based on the Spreiter theory, for rectangular wings also in mid-wing combinations yielding, by an approximation, the total lift coefficient but neglecting the lift distribution.

ZERO-LIFT-DRAG CHARACTERISTICS OF WING-BODY COMBINATIONS AT TRANSONIC SPEEDS. R.T. Whitcomb. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 601. 7 pp. Members, $0.35; nonmembers, $0.75.

investigation of the physical basis and practical applications of the area rule in terms of interpretation, correlation, and improvement of the drag rise characteristics for low-aspect-ratio thin wing-body configurations and bodies of revolution as a function of the axial distribution of cross-sectional area normal to the airstream; analytical results, similar to those obtained from the Hayes linear supersonic theory in the development of the basic relationship of the drag-rise increments for the wing-body combination and the comparable body of revolution due to the general similarities of the major portions of the extensive flow fields of the configurations, applied to the redesign of the fuselage, with a correlation of the effect of external nacelles on the pressure drag considered as the difference between the drag level near the speed of sound and the drag level at supersonic speeds where the drag is primarily due to skin friction.

AEROELASTICITY

APPLICATION OF NUMERICAL INTEGRATION TECHNIQUES TO THE LOW-ASPECT-RATIO FLUTTER PROBLEM IN SUBSONIC AND SUPERSONIC FLOWS. Appendix A---REPRESENTATION OF THE PRESSURE DISTRIBUTION, ITS INTEGRALS AND DERIVATIVES IN TERMS OF POINT VALUES. Appendix B---SUMMARY OF THE INTEGRALS REQUIRED TO EVALUATE THE PRESSURE-VERTICAL VELOCITY RELATION. Appendix C---TABULATION OF FUNCTIONS NEEDED IN THE EVALUATION OF THE PRESSURE-VERTICAL VELOCITY RELATION. Garabed Zartarian, Pao-Tan Hsu, and H.M. Voss. MIT ASRL TR 52-3, Oct. 1, 1954. 195 pp. 57 refs. NavBuAer-sponsored reformulation of the integral equation governing the flutter of a lifting surface with plate-like deformations applying the reverse-flow theory and avoiding the intermediate calculation of the normal modes of vibration to work directly with the structural influence coefficients; analysis includes: a derivation of a numerical integration procedure to obtain the pressure and vertical velocity on a planar wing of arbitrary shape oscillating in subsonic flow; an evaluation of the numerical approach to calculate air forces on arbitrary plan forms in supersonic flow, with a review of existing methods; and a development of an alternative technique based on the division of the plan form into elementary areas bounded by Mach lines.

DRGANIA PODŁUŻNE I POPRZECZNE PRĘTA POD DZIAŁANIEM PULSUJĄCEJ SIŁY OSIOWEJ JAKO ZAGADNIENIE NIELINIOWE (LONGITUDINAL AND TRANSVERSAL VIBRATIONS OF A ROD SUBJECTED TO AXIALLY PULSATING FORCE, TAKING NONLINEAR MEMBERS INTO CONSIDERATION). Kazimierz Piszczek. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 345--362. 10 refs. In Polish, with summaries in English and Russian. Study of the problem of dynamic stability of a rod of constant cross-section with both ends hinged under axial loading, applying the Hamilton principle to deduce the basic system of equations under the assumption of a simplified model in the form of a one-degree-of-freedom system for longitudinal and transverse vibrations and of a further simplifying assumption to eliminate the effects of these vibrations, taking into account the influence of transversal deflections on axial displacements and of the physical nonlinearity represented by stress-strain relations in the form of a third degree polynome with two material constants.

THE EQUIVALENCE OF CONTINUOUS AND DISCRETE MASS DISTRIBUTIONS IN CERTAIN VIBRATION PROBLEMS. R.K. Livesley. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 353--360. Derivation of the expression

$$\frac{{}_{\infty}\omega_s - {}_{n}\omega_s}{{}_{\infty}\omega_s} \simeq 0.2\,(s/m)^2$$

as an approximate relationship, for the frequency error in the case of a uniform simply supported beam in transverse vibration, based on the Duncan numerical results for the cantilever.

ON THE DETERMINATION OF THE FLUTTER FORCES ON WINGS WITH SUPERSONIC LEADING EDGES. B.A. Hunn. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 293--310. Evaluation based on linearized theory of the practical problem to analyze the vibrational forces on swept wings of finite low aspect ratio having straight and supersonic leading and trailing edges and tips straight in the line of flight, using two methods of approach: 1) based on a transformation of variables to permit the ultimate numerical analysis of a certain integral, being valid for all frequency parameters in any comprehensive treatment; and 2) based on a set of potential Lance and Hunn-derived functions, but valid only for small values.

THE PRINCIPAL FREQUENCIES OF VIBRATING SYSTEMS WITH ELLIPTIC BOUNDARIES. S.D. Daymond. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 361--372. Includes analyses of certain fundamental characteristics of eigenvalues, theoretical concepts, and the method of solution for two illustrative elliptic boundary problems using inverse procedures, with tables of functions for the evaluation of derivatives.

PROBE MEASUREMENT OF PRESSURE DISTRIBUTION ON OSCILLATING WINGS IN SUPERSONIC FLOW. Erik Mollø-Christensen, R.L. Halfman and S. Dean Lewis. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 591. 15 pp. Members, $0.50; nonmembers, $0.85. NavBuAer-supported experimental investigation in the MIT variable Mach Number supersonic blowdown tunnel on rigid half-span models on an elastic support in the tunnel roof excited at the resonant frequency of the support by means of an electrodynamic shaker using a wing-velocity signal in a stabilizing feedback circuit to control the amplitude and wave form of the wing oscillations; development of a scanning piezo-electric pressure probe design incorporating a miniature pressure pickup to determine continuous distributions of pressure at a small distance from

the oscillating wing surface rather than directly at the surface, with a detailed description of other test apparatus and techniques; error estimation provides for the effects of disturbed potential flow, the boundary layer on the wing, probe-wing and viscous interaction, and overall interference in three-dimensional flow, with memory and analog methods used for the analysis.

PROBLEMI DI VIBRAZIONE NELLE STRUTTURE DEI VELIVOLI AD ALTA VELOCITÀ (VIBRATION PROBLEMS IN HIGH SPEED AIRCRAFT STRUCTURES). Luigi Broglio. L'Aerotecnica (Rome), Aug., 1955, pp. 171--185. In Italian. Study of the natural vibrational modes and frequencies of shell-wings under the assumption that the variable section of the shell consists of a rectangular box-cell with four main stringers at the corners, each of the top and bottom horizontal sheets being reinforced by n secondary stringers, and of a horizontal axis of symmetry with mass of the wing distributed along it, taking into account the boundary conditions; analysis includes: solutions for the torsional and flexural modes for the case of a constant shell section using a transcendental equation in a simple linearized procedure; and a derivation of equations of dynamic equilibrium of the various elements of the structure in three degrees of freedom for vertical displacement of the centroid (O) of the rectangular section, rotation about the centroid, and axial displacements of the stringers, with calculations for the equations of torsion and bending under the further assumption that the structure and mass distribution are symmetrical in relation to the vertical axis through the centroid.

THE TREATMENT OF DAMPING FORCES IN VIBRATION THEORY. I. R.E.D. Bishop. J. RAeS, Nov., 1955, pp. 738--742. Study of hysteretic or structural damping for forced oscillations with one degree of freedom, taking into account the similarity of viscous principles in a simple system, the difference in the case of the magnitude of force being proportional to the displacement, and the problem of free vibration, in terms of mathematical linearity of equation of motion; includes an analysis of the relation to complex damping as for the case of viscous and hysteretic damping in an anchored spring.

AVIATION MEDICINE

ÉTUDE EXPÉRIMENTALE ET THÉORIQUE DE LA DÉCOMPRESSION EXPLOSIVE ET DE SES EFFETS PHYSIOLOGIQUES. François Violette. France, Min. de l'Air BST 118, 1955. 106 pp. 89 refs. In French. Theoretical and experimental study of explosive decompression and its physiological effects, with a development of a highly accurate recording system to obtain simple expressions of laws applicable to problems of cabin decompression as related to lung reactions, based on classical thermodynamic concepts; includes calculations of the maximum coefficient of the cabin leakage compatible with passenger total safety.

COMPUTERS

ELECTROANALOGIC METHODS. I---SOLUTION OF ELECTRICAL PROBLEMS BY CONTINUOUS-TYPE CONDUCTIVE PROCEDURES. T.J. Higgins. Appl. Mech. Rev., Jan., 1956, pp. 1--4. 111 refs. Review of the literature including experimental factors of electric and magnetic fields, network design as applied to servomechanisms and automatic control systems, microwave component design, electron trajectories, and charged-particle ballistics related to analogical techniques for effecting accurate quantitative solutions of two-dimensional and rotationally symmetric three-dimensional boundary-value problems.

ELECTRONICS

MEASUREMENT OF DAMPING AND NATURAL FREQUENCY. A.B. Kaufman. Instruments & Automation, Dec., 1955, pp. 2,104--2,108. Simple and rapid method for measuring electrical structures using a step-type forcing function and recording of the high-frequency response to indicate the overshoot and frequency of induced oscillation, with definitions of the basic parameters.

NAVY REQUIREMENTS FOR AIR NAVIGATIONAL AIDS, COMMUNICATIONS FACILITIES, AND AIR TRAFFIC CONTROL 1955--1975. H.I. Rothrock. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 598. 10 pp. Members, $0.35; nonmembers, $0.75. Operational planning problems and trends for the Common Civil/Military System consisting of nine different types of technical facilities developed in terms of high operating speeds and altitudes, system accuracy, and basic tactical needs over land and water, with the navigational, communications, and control services providing for such requirements as: automatic information gathering, processing, and display for azimuth and distance data relative to a line of sight distance between two and three hundred nautical miles and an altitude of at least one hundred thousand feet for amphibious warfare; a continuing visual guidance en route and during take-off and landing; automatic pilotage and control of aircraft; and practical, reliable design of components and installations.

FLIGHT OPERATING PROBLEMS

INTEGRATION OF WEATHER FORECASTING, FLIGHT PLANNING, AND FLIGHT WATCH. T.L. Burkett and I.I. Gringorten. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 590. 12 pp. Members, $0.50; nonmembers, $0.85. Development of a meteorological and navigational method for optimum operation with civil and military transport aircraft using a system for representing a wind field varying in time and space on one weather chart, a time-front minimal flight plan, and a simplified computer, taking into account previous

pressure patterns and single heading; includes results of minimal flight investigations, with means to predict wind front and other atmospheric changes and to provide in-flight correction of data.

I---OPTIMALIZING CRUISE CONTROL FOR TURBOJET AIRCRAFT. W.B. Bryant, Y.T. Li, and H.L. Pastan. II---PROGRAMMED CRUISE CONTROL FOR TURBOJET AIRCRAFT. Appendix I---CRUISE RELATIONS FOR TURBOJET AIRCRAFT WITHOUT DRAG RISE LIMITATIONS. Appendix II---CRUISE RELATIONS FOR TURBOJET AIRCRAFT WITH DRAG RISE LIMITATIONS. M. A. Hoffman, Y.T. Li, and A.J. Navoy. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 603. 27 pp. Members, $0.65; nonmembers, $1.00. USAF-sponsored investigations of the basic problem for long-range operations related to the requirements of adjusting airspeed and altitude to maximize the instantaneous specific range in order to develop an optimalizing control technique using a controller of the peak-holding type; analyses of cruise characteristics and dynamic interference effects, with typical curves of hunting performance, taking into account aircraft dynamics, atmospheric turbulence, and safety factors; design of an instrumentation scheme based on "invariable cruise parameters" to provide compensation for inertial lag, nonlinear variations of drag with airspeed, the effects of inaccuracies in fuel flow and airspeed measurements, smoothing the computed specific range, and for improving performance through closed-loop airspeed control and throttle programming; evaluation of airborne and other navigational aids including those for constrained cruise of Mach-limited aircraft.

FLIGHT TESTING

ANALYTICAL PHOTOGRAMMETRY AS APPLIED TO FLIGHT TESTING. Hellmut Schmid. Photogrammetric Eng., Dec., 1955, pp. 680--685. Data on experimental measuring methods used at the Ballistic Res. Labs., Aberdeen Proving Ground, for determining trajectories of various types of guided missiles, airborne test vehicles directly or remotely controlled, and free-flight ballistic missiles in short, moderate, and long-range flight.

FLIGHT TESTING TECHNIQUES & ANALYSIS: DETERMINATION OF FREQUENCY RESPONSE CHARACTERISTICS, INCLUDING COUPLING TENDENCIES, DURING STANDARD AIR FORCE PHASE TESTS, WITH RESULTS ON AN F-86D AT M=.85. F.O. Smetana. USAF AFFTC TR 54-19, May, 1955. 241 pp. 47 refs. Edwards AFB Flight Test Center development of a method applying flight test data to derive frequency response curves to obtain the response to any arbitrary control input, taking into account fundamental theoretical principles and such factors as dynamic motions of an aircraft, target tracking, guidance, fire-control systems, transfer functions, frequency-dependent body response, and control-surface deflections.

ICE FORMATION & PREVENTION

IMPINGEMENT OF WATER DROPLETS ON A SPHERE. Appendix---DESCRIPTION OF LEWIS ELECTROMECHANICAL DIFFERENTIAL ANALYZER. R.G. Dorsch, P.G. Saper, and C.F. Kadow. US, NACA TN 3587, Nov., 1955. 29 pp. 10 refs. Calculation of droplet trajectories in ideal fluid flow to determine the droplet-impingement characteristics of the sphere for the design and evaluation of aircraft thermal icing-protection systems, with data and equations for the collection efficiency, the area, and the impingement distribution given in terms of dimensionless parameters, and with the range of flight and atmospheric conditions extended considerably beyond the previously covered range.

IMPINGEMENT OF WATER DROPLETS ON NACA 65A004 AIRFOIL AT 0° ANGLE OF ATTACK. R.J. Brun and D.E. Vogt. US, NACA TN 3586, Nov., 1955. 28 pp. Calculation of the amount, area, and rate of droplet impingement per unit area from the trajectories covering a large range of flight and atmospheric conditions, as compared to data obtained on the same airfoil at angles of attack of 4° and 8°.

INSTRUMENTS

IMPROVED ON-OFF MISSILE STABILIZATION. R.W. Bass. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 589 (ARS Preprint 285-56). 11 pp. Members, $0.25; nonmembers, $0.50. ONR-supported development of a general theory for the synthesis of on-off servosystems rendered statistically stable by a true "predictor network" involving none of the side-effects, such as chattering of the conventional anticipatory networks, and completely eliminating the delays from the system for step-inputs and ramp-inputs through combining of the conventional linear error and error-rate feedbacks with nonlinear feedback from the on-off control element itself.

MACHINE ELEMENTS

WYTRZYMAŁOŚCIOWE OBLICZANIE WIRUJĄCYCH TARCZ MASZYN CIEPLNYCH WIRNIKOWYCH (CALCULATION OF STRENGTH IN ROTATING DISCS OF GAS TURBINES). Edmund Tuliszka. Arch. Budowy Maszyn (Warsaw), No. 3, 1955, pp. 227--263. In Polish, with summaries in English and Russian. Analysis includes: calculations for hyperbolical rings loaded with inertial forces of rotating masses and stresses resulting from the temperature field and from the shrinkage setting of the discs on the shaft, taking into account variable revolutions up to freeing levels; determination of the field of temperatures for the case of heating of the discs exclusively by means of gas flowing

through the channels between the blades, with measurements on the interstage leakage; and use of the superposition method to solve the problem of boundary conditions of the stress states in terms of the temperature of the shaft and the properties of the blade rim with regard to the exchange.

MATERIALS

THE EFFECT OF COLD WORK ON THE STRESS CORROSION RESISTANCE OF ALUMINIUM-ZINC-MAGNESIUM ALLOYS. Ryoji Watanabe and Mituru Sawada. J. Hokkaido Gakugei U., Sect. B, Sept., 1955, pp. 24--27. In Japanese. Tests at 80°, 100°, 120°, 140°, and 160°C. on an aluminum alloy with 9% Mg and 2% Zn to determine high-temperature aging results.

METALLOGRAPHY OF ALUMINUM AND ITS ALLOYS; USE OF ELECTROLYTIC POLISHING. I---BIBLIOGRAPHY OF METALLOGRAPHIC APPLICATIONS OF ELECTROLYTIC POLISHING OF ALUMINUM AND ITS ALLOYS. II---DESCRIPTION OF SEVERAL MICROGRAPHIC TECHNIQUES USING ELECTROLYTIC POLISHING. III---EXPERIMENTAL INVESTIGATION REGARDING USE OF AN AUTOMATIC APPARATUS FOR ELECTROLYTIC POLISHING. Appendix---CASE OF ELECTRO-MICROGRAPHIES. P.A. Jacquet. (France, ONERA Pub. 51, 1952.) US, NACA TM 1384, Nov., 1955. 49 pp. 157 refs. Translation. Comprehensive review of the literature covering technical developments and problems of light and ultralight alloys, and of the micrographic procedures and control methods used in terms of particular applications.

FAILURE OF MATERIALS UNDER COMBINED REPEATED STRESSES WITH SUPERIMPOSED STATIC STRESSES. Appendix A---ANALYSIS OF STRESSES AT CRACKS OF VARIOUS ORIENTATIONS. Appendix B---TRANSFORMATION OF GENERAL CRITERION INTO TERMS OF MAXIMUM AND MINIMUM STRESS RATIO. George Sines. US, NACA TN 3495, Nov., 1955. 69 pp. 45 refs. Review of experiments on biaxial alternating stresses and simple combinations of static stresses to determine the effect of static compression on alternating torsion from test results; development of a general criterion for this effect on the permissible amplitude of alternating stress, with a comparison to results obtained with more complex stress states; includes modifications of the Orowan fatigue theory to predict the effect of mean stress.

MATERIALS AND FABRICATION TECHNIQUES FOR STRUCTURAL HEAT RESISTANT PLASTIC SANDWICHES. N.E. Wahl. (CAI-IAS Internatl. Meeting, Ottawa, Nov. 3, 4, 1955, Preprint 571.) Aero. Eng. Rev., Feb., 1956, pp. 34--36. Review of developments at the Cornell Aero. Lab. of non-metallic high-strength, heat-resistant materials, formations, and processes for a foamed-in-place core material to obtain such characteristics as satisfactory electrical and mechanical properties, adhesion at the interface between the core and the glass-reinforced laminate skin with shear strength in excess of 100 psi, uniform structure of small foam cell size, homogeneity with no voids over 1/8 in. in diameter, and ease of handling in sandwich designs involving compound curved shapes; work program includes an investigation of wing design and structure, fabrication of prototype wing and two wing sections, mold design and construction, and a comparison to the conventional missile wing; analysis includes data on average compressive strength versus density of Polyurathane foam from Laminac 4231 and average flatwise compression and flexural or bending strength for 10 lb.-density foam.

SOME EXPERIMENTS INTO THE BEHAVIOUR OF PLAIN AND NOTCHED STEEL SPECIMENS UNDER STATIC AND FATIGUE LOADINGS. Appendix I---PHYSICAL AND METALLURGICAL PROPERTIES OF THE MATERIAL. Appendix II---NEUBER'S EQUATIONS. Appendix III---FATIGUE-TESTING MACHINES. J.W. Fitchie. IME Proc., No. 18, 1955, pp. 331--344. 13 refs. Investigation to determine the true stress field at the base of a notch in test specimens when loaded within and beyond the elastic range, taking into account the reproducible physical and metallurgical properties, the constancy, stability, and isotropic modes of the structure; ductility and continuity in the change from the elastic to the plastic region; and stress concentration sensitivity.

MATHEMATICS

ASYMPTOTIC SOLUTIONS OF MAXWELL'S EQUATIONS INVOLVING FRACTIONAL POWERS OF THE FREQUENCY. Morris Kline. Commun. on Pure & Appl. Math., Nov., 1955, pp. 594--614. 10 refs. USAF-sponsored research, with results applicable to the solution of such problems as electromagnetic and acoustic scattering by a semi-infinite body of revolution and diffractional behavior.

ON THE BOUNDS OF EIGENVALUES. K. Washizu. Quart. J. Mech. & Appl. Math., Sept., 195[illegible] pp. 311--325. Geometric representation of leading theorems, generalization of the Rayleigh principle as used to estimate natural frequencies of vibrating systems, and potential extension to a system with an infinite number of degrees of freedom.

MISSILES

GROWING A RELIABLE MISSILE. R.R. Carhar[illegible] Aero. Eng. Rev., Feb., 1956, pp. 28--33. Basic concepts of component reliability viewed as a growth process to achieve system design requirements, limitations in the component approach, and recom-

mendations on criteria and means to focus improvement efforts at the subsystem level to relate more closely the requirements of component testing to those of system reliability in terms of operational and potential performance and failures under varying environmental and other conditions of propulsion units, air frames, controls, and guidance devices, taking into account the probability basis and such factors as mission objectives, input and output functions, design specifications, and tolerances.

PHOTOGRAPHY

THE NEW AIR FORCE PHOTOALIDADE. W.D. Cannell. Photogrammetric Eng., Dec., 1955, pp. 664--668. Developmental and operational characteristics of the Wilson design to determine ground elevations from oblique photography of the type used in the compilation of aeronautical charts requiring great flexibility in format, focal length, and depression angles; includes a description of charting procedures and techniques.

POWER PLANTS

FUEL SYSTEMS FOR GAS TURBINE ENGINES. O.N. Lawrence. J. RAeS, Nov., 1955, pp. 727--737. Analysis of the basic problems: air intakes, taking into account the Greatex research findings on high subsonic conditions and the design of actuating mechanisms; general control factors for aircraft propulsion units of multi-shaft and turbo-propelled engines, flow ranges, and filtration and deicing of fuel; pump design and pressure requirements; burners, in terms of settings of pressure levels; acceleration and combined controls and density-free governors; and reheat, dependent on jet pipe temperature of the main engine, on the pressure ratio across the turbine for the main engine, and on the fuel-to-air ratio system; the application of the theory of servomechanisms to practical fuel system design; and weight estimates tabulated for various components.

SUL COMPORTAMENTO DELL'AUTOREATTORE AL VARIARE DELLE CONDIZIONI DI IMPIEGO NEL CAMPO SUPERSONICO (ON THE BEHAVIOUR OF A RAM-JET IN DIFFERENT OPERATIONAL CONDITIONS AT SUPERSONIC SPEEDS). Corrado Casci. L'Aerotecnica (Rome), Aug., 1955, pp. 195--202. In Italian. Calculations in simple form of the air mass flow and specific thrust ratios under the assumption that the engine is controlled thermometrically, and that the velocity of the exhaust gases is of the order of magnitude of the sound velocity with the mass flow depending only on the upstream conditions; deduction of the variation of thrust and consumption ratios at variable Mach Numbers and altitude, with analytical diagrams indicating optimum performance in the Mach range of 1.8--2.2 at approximately 3,350 --9,750 ft.

DEMONSTRATION OF RELIABILITY IN LIQUID PROPELLANT ROCKET ENGINES. A.G. Thatcher and H.A. Barton. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 588 (ARS Preprint 284-56). 11 pp. Members, $0.25; nonmembers, $0.50. Statistical approach to basic problems generalizing design and development testing programs in terms of fundamental probability criteria based on the assumption of no operational failure of a given component within design performance limits, thus creating a degree of assurance for reliability standards related to exacting environmental test and flight conditions as applied to missile research.

ROCKET PERFORMANCE WITH HEAT ADDED TO INLET PROPELLANTS BY REGENERATIVE AND EXTERNAL MEANS. G. Banerian. Jet Propulsion, Dec., 1955, pp. 707--711. Investigation based on the simplified assumptions of pure-gas laws and one-dimensional flow dynamics to determine the effects of heat transfer on the over-all specific impulse for the cases of regenerative cooling only during the whole expansion process and at only one station in the thrust chamber without friction, exhaust heat recovery or of heat recovery from any outside source similarly without friction, and regenerative heat transfer with friction; analysis includes graphical data on the specific impulse versus the pressure ratio for varying friction coefficients, with results applicable to problems of missile skin friction or reactors.

ROTATING WING AIRCRAFT

THE HELICOPTER---HAS IT A FUTURE? F.H. Robertson. J. RAeS, Nov., 1955, pp. 762--771. Developmental appraisal of design problems, trends, and actual and potential utilization in terms of requirements of simplicity, long life or integrity, safety, and initial first cost and economic operation; includes: definitions of pure, compound, and convertible types; a tabular breakdown of tasks most suitable for helicopter adaptation; insurance, maintenance and repair, fuel and oil, and other cost data related to payloads; and an evaluation in terms of possible competition from jet-lift VTO aircraft.

DETERMINATION OF INFLOW DISTRIBUTIONS FROM EXPERIMENTAL AERODYNAMIC LOADING AND BLADE-MOTION DATA ON A MODEL HELICOPTER ROTOR IN HOVERING AND FORWARD FLIGHT. Gaetano Falabella, Jr., and J.R. Meyer, Jr., US, NACA TN 3492, Nov., 1955. 184 pp. 10 refs. Analyses of test results on azimuth and spanwise inflow distributions from pressure and blade-motion recorded measurements for various rotor conditions at tip-speed ratios of between 0.10--1.00, with data of the effects of operation with a one-blade-rotor and with a rotor having 13° -offset flapping hinge, deliberate blade stall, and cyclic pitch; includes plots of loading and inflow ratio contours for rotor operation at 0.30-and zero-and 13-per cent offsets used for purposes of comparison.

THE EFFECT OF BLADE ROOT PROPERTIES ON THE NATURAL MODE SHAPES, BENDING MOMENTS, AND SHEARS OF A MODEL HELICOPTER ROTOR BLADE. H. Daughaday and F. DuWaldt. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 595. 15 pp. Members, $0.50; nonmembers, $0.85. USAF-sponsored investigation at Cornell Aero. Lab. of the associated problems of rotor flutter and the vibration response of rotor blades, with computations of the natural vibration modes at the operating shaft angular velocity and in the nonrotating condition for four different root fitting configurations indicating the influence of the root flapping fitting and blade attachment on the blade bending moment distributions and vertical shears due to blade vibrations and the relative importance of the moment inertia of the root flapping fitting as the prime parameter rather than the bending stiffness; includes calculations of the weight and stiffness distributions for the model.

RESPONSE MATRIX METHOD OF ROTOR BLADE ANALYSIS. Alex Berman. J. Aero. Sci., Feb., 1956, pp. 155--161, 172. Formulation of a technique to calculate the bending moment, curvature, slope, deflection, rotating modes, and natural frequencies of the blade response for any loading and harmonic without repeating solutions of the differential equation by post-multiplying the appropriate "response matrix" by a column matrix representing the rigid blade distribution, with calculations of the response matrices for any of the higher harmonics using natural frequencies and modes of the rotating beam measured from the zeroth harmonic, response matrices for which are calculated directly by tabular means.

THE STIFF-HINGED HELICOPTER ROTOR, A NEW FORM OF ROTOR GIVING IMPROVED PERFORMANCE AND STABILITY. P.R. Payne. Aircraft Eng., Nov., 1955, pp. 358--370. 15 refs. Investigation of the effect of elastic stiffness, as a function of the bending strength of the blade root, in the flapping hinge, and the effect on blade flapping control angles to trim, control response, hovering stability, permissible C.G. travel, angle of attack distribution, and retreating blade stall; design incorporating elastic restraint permits practical realization of the aerodynamic advantages of high offset allowing the use of a lighter and simpler hub assembly and removing any obvious limitation, with the exception of shock stall of the advancing blades, to the maximum speed attainable by a helicopter.

SAFETY

AIR SAFETY; A REPORT ON THE SEVENTH ANNUAL AIR SAFETY SEMINAR, HELD IN TAXCO, MEXICO, NOVEMBER 17--20, 1955. O.E. Kirchner. Aero. Eng. Rev., Feb., 1956, pp. 48--53. Seminar coverage on problems of turbulence, vortex wakes, pilot stress in accidents, traffic density, decompression, bird strikes, high-speed evacuation, crash rescue, and crash-survival lessons; includes details of such installations as crash location beacon, crash-resistant fuel tanks, collision lights, Tacan, Mexican navigational aids, backward facing seats, and visual aids for airport indoctrination; description of SAC experiments with jets, Air Defense Command interception, survival in the Tropics, safety cooperation, and the cabin attendants' problem.

STRUCTURES

EFFECT OF YIELDING ON THE FATIGUE PROPERTIES OF TEST PIECES CONTAINING STRESS CONCENTRATIONS. K. Gunn. Aero. Quart., Nov., 1955, pp. 277--294. Development of an estimating method to determine fatigue properties of notched test pieces subjected to cyclic loads applied in the presence of mean stresses, with the initial assumptions based on a modified Goodman relationship between Range of Stress and Mean Stress, and taking into account the local yielding occurring near the base of the notch when the nominal stresses are sufficiently high.

O PEWNEJ METODZIE WYZNACZANIA PÓL TOLERANCYJNYCH (ON A CERTAIN METHOD OF DETERMINING TOLERANCE FIELDS). Wojciech Szczepinski. Arch. Budowy Maszyn (Warsaw), No. 3, 1955, pp. 275--284. In Polish, with summaries in English and Russian. Application of the Maxwell-Mohr method to the analysis of dimension nets of bars formed by a series of triangles adhering to one another to determine the tolerance field of an arbitrary point.

O PEWNYM RODZAJU NIEJEDNORODNOŚCI OŚRODKÓW CIĄGŁYCH (ON A TYPE OF HETEROGENEITY OF ELASTIC BODIES). Jerzy Litwiniszyn. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 301--314. In Polish, with summaries in English and Russian. Solution of the problem of creep in particular types of heterogeneous linear rheologic bodies described by the equation of state based on a transformation of Lagrangian co-ordinates to determine material constants, with a derivation of the general equation of motion for one-dimensional bodies, and with the analysis for the simple case of longitudinal vibration of a string of natural heterogeneity using the equation of dynamic equilibrium in the form of a quasi-linear equation related to the density type of the elastic constant.

STRESS DISTRIBUTION, INSTABILITY, AND FREE VIBRATION OF BEAM GRID-WORKS ON ELASTIC FOUNDATIONS. H.L. Cox and P.H. Denke. J. Aero. Sci., Feb., 1956, pp. 173--176. Approximate method for finding the stress distribution, buckling load, and lowest natural frequency for a beam grid-work structure on an elastic foundation for variable load distributions, beam and foundation stiffnesses, and boundary conditions; includes an appraisal of the applicability of the method

for use in conjunction with electronic digital computation reducing the work of stress analysis through a matrix formulation of the basic problem.

Beams & Columns

ON THE BEHAVIOUR OF INFINITELY LONG RIGID-PLASTIC BEAMS UNDER TRANSVERSE CONCENTRATED LOAD. H. G. Hopkins. J. Mech. & Phys. Solids, Oct., 1955, pp. 38--52. Study under the assumption that the effects of transverse shearing deformation and rotatory inertia are negligible with the yield condition dependent only upon the bending moment to obtain solutions for the condition that the ratio of the impact velocity of the concentrated load to the time is nonincreasing in time and for the associated problem concerned with the motion of the beam following the removal of the concentrated load, with the results of the general analysis applied to solve completely the constant-impact velocity problems, having as its motion characteristic a central, fixed yield-hinge and two lateral, outwards-moving yield-hinges under the condition that the beam does not come to rest at any finite time.

THERMAL STRESSES AND DEFORMATIONS IN BEAMS. Samuel Levy. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 576. 19 pp. Members, $0.50; nonmembers, $0.85. Derivation of general formulas for computing the thermal stresses and curvature in a long beam when the rise in temperature at any location in the beam cross-section is given and when the coefficient of expansion and Young's modulus are known functions of temperature, using simplifying assumptions to determine the temperature, maximum tensile and compressive stresses, and curvature as a function of time for a beam such as a wing subjected to constant aerodynamic heating on one side and to determine the recovery factor as the ratio of the equilibrium temperature rise to the stagnation temperature rise which is approximately proportional to the square of the speed analyzed in terms of the aerodynamic behavior of air in the vicinity of the surface.

TRANSIENT FLEXURAL STRESSES IN AN INFINITE BEAM. R.P.N. Jones. Quart. J. Mech. & Appl. Math., Sept., 1955, pp. 373--384. Solution based on Timoshenko theory of transverse vibrations of the problem of an infinite beam under a point load using Fourier transforms to obtain asymptotic approximations by the method of stationary phase for the shear force and bending moment in the beam.

TRANSIENT STRESSES IN AIRFOILS SUBJECTED TO BLAST LOADING. F. J. Marshall and H.F. Ludloff. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 604. 23 pp. Members, $0.65; nonmembers, $1.00. Development of an exact solution applying the Laplace transformation of an initial-boundary value problem for the Timoshenko equations such that the point of discontinuity of the loading is allowed an arbitrary magnitude to exceed the propagation velocity of the elastic waves in the Timoshenko beam, with the analysis based on results of tests on a wing treated as a Timoshenko beam with a discontinuous forcing or load-intensity function and subjected to the pressure distribution of a particular diffraction pattern resulting from a blast front hitting the wing tip; includes calculations of the energy within the beam; the efficiency of the load-to-beam transmission; the behavior of shear, bending moment, and linear and angular velocity using series expansion for small times and the saddle-point method for large times.

Connections

CORRELATED FATIGUE DATA FOR AIRCRAFT STRUCTURAL JOINTS. Appendix---DERIVATION OF AVERAGE JOINT CURVE. R.B. Heywood. Gt. Brit., RAE Rep. Struc. 184, June, 1955. 16 pp. Test results on extruded, rolled, or forged aluminum alloy members in the form of S-Log N curves, taking into account such factors as the type of alloy, the ultimate tensile strength, and the mean and alternating stresses of the fatigue cycle.

INVESTIGATION OF THE USE OF A RUBBER ANALOG IN THE STUDY OF STRESS DISTRIBUTION IN RIVETED AND CEMENTED JOINTS. Appendix A---METHOD OF COMPUTING NORMAL AND SHEAR STRESSES. Appendix B---CEMENTED-JOINT ANALYSIS. Appendix C---A CONSIDERATION OF PROBLEMS INTRODUCED BY BENDING AT ENDS OF SINGLE LAP JOINTS. Appendix D ---METHOD OF CORRECTING PARALLAX ON X-RAY NEGATIVE. L.R. Demarkles. US, NACA TN 3413, Nov., 1955. 97 pp. 21 refs. MIT study using displacement measurements from foam-rubber analogs to indicate distribution of shear in the joints considered nonuniform over the length of the joints but greater near the ends than in the middle as long as the stresses are kept within the elastic range where most fatigue loads occur.

Cylinders & Shells

COMPARISON BETWEEN THEORETICAL AND EXPERIMENTAL STRESSES IN CIRCULAR SEMI-MONOCOQUE CYLINDERS WITH RECTANGULAR CUTOUTS. H.G. McComb, Jr., and E.F. Low, Jr. US, NACA TN 3544, Oct., 1955. 20 pp. Analysis includes stresses in the stringers and shear stresses in the center of the shear panels in the vicinity of the cutout, taking into account the bending flexibility of the structural rings as a prime factor in calculating stresses about cutouts.

THE INFLUENCE OF FREE ENDS ON THE LOAD-CARRYING CAPACITIES OF CYLINDRICAL SHELLS. G. Eason and R.T. Shield. J. Mech. & Phys. Solids, Oct., 1955, pp. 17--27. Extension of the Drucker theory of axially symmetric plastic load-

ing of thin circular cylindrical shells of infinite length to the case of shells of varying lengths under the assumption that the ends of the shells are stress free for a ring of force and a band of uniform pressure.

KRYTYCZNE OBCIĄŻENIE PRZY SKRĘCANIU CYLINDRYCZNEJ POWŁOKI ORTOTROPOWEJ O SKOŃCZONEJ DŁUGOŚCI (CRITICAL LOAD OF A CYLINDRICAL ORTHOTROPIC SHELL OF FINITE LENGTH, SUBJECTED TO TORSION). Zdzisław Parszewski. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 375--403. In Polish, with summaries in English and Russian. Analysis of the basic problem in terms of a solution comprising the case of a shell of orthotropic material reinforced with stiffening ribs, with a determination of the condition of stability based on equations of the equilibrium for a buckling shell taking into account the general cases of built-in and supported edges related to the factors of critical forces and of critical loading as a function of the parameters of the shell geometry.

O NIECIĄGŁYCH ROZWIĄZANIACH RÓWNAŃ STATYKI BUDOWLI METODĄ TRANSFORMACJI LAPLACE'A NA PRZYKŁADZIE BELKI O SZTYWNOŚCI ODCINKAMI ZMIENNEJ (DISCONTINUOUS SOLUTIONS OF THE EQUATIONS OF STRUCTURAL STATICS OBTAINED BY MEANS OF THE LAPLACE TRANSFORMATION AND ILLUSTRATED BY THE EXAMPLE OF A BEAM OF SECTIONALLY CONSTANT RIGIDITY). Tadeusz Iwiński. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 494--418. In Polish, with summaries in English and Russian. Problem analysis in applying the Laplace transform to solve the differential equations of structural statics, with a development of a method for establishing adequate conditions based on the example of a beam of sectionally constant rigidity subjected to an arbitrary vertical load, and with calculations of the discontinuities of the deflection line.

SPRĘŻYSTO-PLASTYCZNY GRUBOŚCIENNY WALEC NIEJEDNORODNY POD DZIAŁANIEM PARCIA WEWNĘTRZNEGO I SIŁY PODŁUŻNEJ (A HETEROGENEOUS THICK-WALLED ELASTIC-PLASTIC CYLINDER SUBJECTED TO INTERNAL PRESSURE AND LONGITUDINAL FORCE). W. Olszak and W. Urbanowski. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 315--336. 18 refs. In Polish, with summaries in English and Russian. Investigation based on the assumption that the end surfaces are prevented from axial displacement and the radial deformation remains unrestrained, with calculations using the differential equations of equilibrium and compatibility to obtain the stress and strain deviators, stress components in the elastic region, radius of the limit cylinder separating the two regions, the value of the first critical pressure corresponding to the appearance of the first plastic deformation on the internal surface of the cylinder, and the second critical pressure; includes an analysis of a particular case where the whole of the cross-section passes to the plastic range simultaneously omitting the elastic-plastic phase.

THREE-DIMENSIONAL AND SHELL THEORY ANALYSIS OF AXIALLY-SYMMETRIC MOTIONS OF CYLINDERS. G. Herrmann and I. Mirsky. Columbia U. Inst. Air Flight Struc. AF TN 1, Apr., 1955. 32 pp. 21 refs. Study to derive quantitative criteria for the range of applicability of shell theories through a comparison of theoretical findings of various investigations providing good agreement with solutions of three-dimensional equations for short wave lengths in accordance with the Mindlin plate theory under the assumption of an infinite shell.

Plates

ANALYSIS OF STRESSES IN THE PLASTIC RANGE AROUND A CIRCULAR HOLE IN A PLATE SUBJECTED TO UNIAXIAL TENSION. Appendix A---SIMPLIFICATION OF MODIFIED COMPLEMENTARY ENERGY EXPRESSION. Appendix B---EVALUATION OF TWO LINE INTEGRALS. Appendix C---DESCRIPTION OF NUMERICAL MINIMIZATION PROCEDURE. Bernard Budiansky and R. J. Vidensek. US, NACA TN 3542, Oct., 1955. 39 pp. 10 refs. Approximate theoretical solution based on the simple deformation theory of plasticity developed by applying a variational principle in conjunction with the Rayleigh-Ritz procedure and the use of a high-speed computer (SEAC) for four different materials with distinct uniaxial stress-strain curves; comparison of results for the stress concentration factor with those obtained using the Stowell formula.

THE INEXTENSIONAL THEORY FOR THIN FLAT PLATES. E.H. Mansfield. Quart. J. Mech & Appl. Math., Sept., 1955, pp. 338-352. Simplified large-deflection theory applied to cantilever and other thin plates subjected to normal loading resisted primarily by the flexural rigidity of the plate rather than by the extensional rigidity, under the assumption that the middle of the plate is inextensional in order that the mode of deformation be a developable surface to permit solution of the basic problem reduced to a one-dimensional nonlinear differential equation of the second order, or when coupled with an energy technique to obtain an approximation solution; analysis indicates nonvalidity of the principle of superposition for different load systems, although for any given type of loading the deflection is proportional to the load.

A NOTE ON THE MINIMUM WEIGHT DESIGN OF A THIN-WALLED STIFFENED RECTANGULAR CELL SUBJECTED TO TORSION. S. Krishnan and V. Cadambe. J. Aero. Soc. India, Aug., 1955, pp. 43--47. Analysis in terms of the failure of plate elements from buckling, with a development of optimum criteria based on the critical shear stress, torque, and twist limits.

ON THE COMPLEX REPRESENTATION OF THE GENERAL EXTENSIONAL AND FLEXURAL PROBLEMS OF THIN PLATES AND THEIR ANALOGIES. Yi-Yuan Yu. J. Franklin Inst., Oct.,

1955, pp. 269--282. Generalization of the Muschelisvili-Lechnitzky method to include the effect of the body force and the lateral load, with a derivation of boundary equations to solve illustrative circular-plate problems related to the indefinite and the line integrals of a nonanalytic function in the complex plane.

THE STRESS ANALYSIS OF FLAT STIFFENED PANELS WITH CUT OUTS. B.C. Hoskin. Australia, ARL S&M Monogr. 3, Feb., 1955. 134 pp. 109 refs. Theoretical bases and relative merits of the stringer-sheet, finite-stringer, PIBAL, substitute-stringer, and strain-energy methods, with a comparative review of the literature covering published experimental results in terms of illustrative examples of solutions, particularly for the case of a tension panel having a rectangular cut out in its interior; includes evaluations of the validity of the assumptions covering continuous and no-slip joints, bending stiffnesses of the ribs, skins effective only in shear, and longitudinal stiffeners; and of the applicability of the various methods for the different types of panel problems.

Thermal Stress

APPROXIMATE PROCEDURES FOR TRANSIENT THERMAL STRESSES IN MISSILE STRUCTURES. B.E. Gatewood. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 578. 15 pp. 17 refs. Members, $0.50; nonmembers, $0.85. USAF Inst. of Tech. analysis, in terms of material, geometry, and time parameters, providing nondimensional form results of an approximation solution for four-dimensional temperature and thermal stress problems involving time and three-space variables and using two idealized aircraft structures for the cases of temperature varying with time alone and with time and thickness; includes determinations of various skin and stringer temperatures, constant heat sources, and edge restraints.

CIEPLNE STANY NAPRĘŻENIA W GRUBOŚCIENNYM NACZYNIU KULISTYM, KTÓREGO MATERIAŁ PRZEJAWIA TZW. IZOTHROPIĘ POPRZECZNĄ (THERMAL STRESSES IN A THICK-WALLED SPHERICAL VESSEL OF TRANSVERSALLY ISOTROPIC MATERIAL). Jerzy Nowiński. Arch. Mech. Stosowanej (Warsaw), No. 3, 1955, pp. 363--374. In Polish, with summaries in English and Russian. Graphical study of the temperature distribution symmetrical in respect to the center in a spherically anisotropic vessel under steady heat flow; calculation of values of constants and stresses applying the Young modulus equal to the modulus of anisotropy.

EXPERIMENT AND THEORY IN THE INVESTIGATION OF THE BEHAVIOR OF STRUCTURES AT HIGH TEMPERATURES. N.J. Hoff. (CAI-IAS Internatl. Meeting, Ottawa, Nov. 3, 4, 1955, Preprint 572.) Aero. Eng. Rev., Feb., 1956, pp. 39--47. USAF-NACA-ONR-sponsored study at the Bklyn. Polytech. Inst. of thermal buckling and stresses and the effect of creep on the stress distribution, taking into account the Soderberg calculations on stress relaxation in terms of the creep law of the material concerned; includes a description of the bending and flexural creep test rig, creep oven, tensile-torsional, and other testing equipment.

EXTREMUM PRINCIPLES OF THE THERMAL ELASTO-PLASTIC STRESSES. Toshio Mura. J. Japan Soc. Aero. Eng., Sept., 1955, pp. 215--220. In Japanese. Conceptual development of principles to determine practical design criteria for the analysis of temperature-dependent structural problems such as fracture and creep of supersonic aircraft, taking into account physical properties of metals and alloys and using iso-thermal tests related to work-hardening temperature ranges.

HIGH TEMPERATURE EFFECTS IN AIRCRAFT STRUCTURES. N.J. Hoff. Appl. Mech. Rev., Nov., 1955, pp. 453--455. 62 refs. Analytical review of the literature covering such factors as the reduction of strength and stiffness at moderate temperatures, creep and thermal stresses and buckling, and the effects of creep on stress distribution and failure.

INFLUENCE OF AERODYNAMIC HEATING ON THE EFFECTIVE TORSIONAL STIFFNESS OF THIN WINGS. Appendix A. Appendix B---FREE-END EFFECT ON THERMAL STRESS AND TORSIONAL STIFFNESS. Bernard Budiansky and J. Mayers. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 579. 27 pp. Members, $0.65; nonmembers, $1.00. Theoretical results, based on the "sheet-stringer" type of approximate elasticity theory, for solid wings of symmetrical double-wedge cross section accelerated to supersonic speeds, taking into account the effects of such parameters as Mach Number, instantaneous and finite acceleration, and thickness ratio, with time calculations of the temperature in the wing section based on the assumption that the heat-transfer coefficient governing the heat flow from the boundary layer to the wing is constant along the chord but varying with time and that the temperatures are constant through the wing thickness at each chord station, neglecting the spanwise and chord heat conduction and radiation effects; includes calculations for the change in the first natural torsional frequency of the wings considered as free-free beams.

INVESTIGATION OF THE TEMPERATURE DISTRIBUTION AND THERMAL STRESSES IN A HYPERSONIC WING STRUCTURE. M.A. Goldberg. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 577. 19 pp. 15 refs. Members, $0.50; nonmembers, $0.85. Tests on an idealized stiffened skin stringer "T" panel divided into 15 sections and isolated out of a multicell wing for the analysis of conduction through the structural members on the basis of heat-input

assumptions similar to those of Pohle and Oliver but improved to allow the effects of time-varying the heat-transfer coefficient and boundary-layer temperature for inclusion in the calculations, and neglecting conduction, convection, and radiation through the air trapped within the structure, taking into account the results of the Torda-Hoff and Barzelay-Boison investigations and of the influence of the ratio of web depth to the span of the skin on the variations of thermal stresses; results indicate that the heat flux entering the system from aerodynamic heating, calculated in terms of a predetermined flight plan, varies sinusoidally with time, remaining constant with position and being equal to the heat flux entering the section at a station midway between the stiffeners.

A STUDY OF THE STRESS-ANALYSIS AND STRUCTURAL-TESTING PROCEDURES APPLICABLE TO AIRCRAFT STRUCTURES AT ELEVATED TEMPERATURES. H.G. Allen, M.A. Brull, and W.J. Wilkie. USAF WADC TR 54-499, Oct., 1954. 119 pp. 42 refs. Conceptual development, based on the Boltzmann "hereditary theory" on the internal mechanical dissipation of energy accompanying any stress cycle, of a method to predict static and dynamic responses related to the behavior of inelastic materials, with the influence of past loading on the studied material response taken into account through the introduction of a stress-strain relationship function; includes application of the theory of time-dependent elasticity and the design of a thermal-stress simulator oven container and loading system.

THERMODYNAMICS

ELEMENTI DI GASDINAMICA DELLE MISCELE (ELEMENTS OF GASDYNAMICS OF MIXTURES). II. Gianni Jarre. L'Aerotecnica (Rome), Aug., 1955, pp. 186--194. 10 refs. In Italian. Application of the fundamental principles of classical molecular theory to problems of heat transference in the development of formulations of the energy-equation; analysis of the phenomena of viscosity, conduction, and diffusion using thermodynamic methods for irreversible processes, with an evaluation of the hypotheses of these processes, particularly the Onsager theorem, as being basic to the kinetic theory of gases.

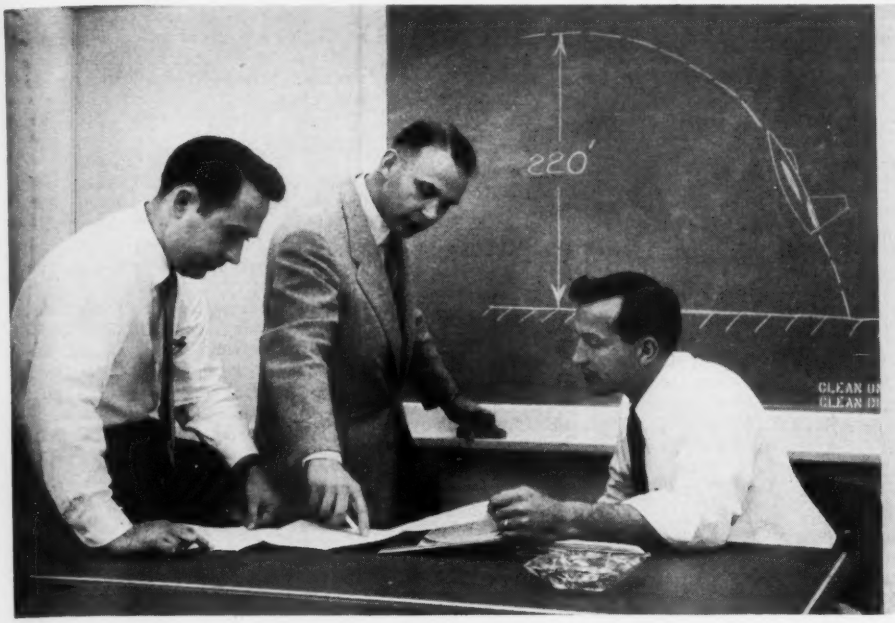
VERTICAL TAKE-OFF AIRCRAFT

EXAMINATION OF SOME OF THE PROBLEMS INVOLVED IN THE DESIGN OF PROPELLER-DRIVEN VERTICAL-TAKE-OFF TRANSPORT AIRPLANES. M.O. McKinney, R.E. Kuhn, and J.B. Hammack. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 597. 19 pp. 12 refs. Members, $0.50; nonmembers, $0.85. Summary of NACA experimental investigations covering stability and control, propellers, and aerodynamic characteristics of wing-propeller combinations indicating the feasibility of using the principle of redirecting the slipstream to obtain turning angles of the order of 70° in order to study the possibilities of developing VTO transports; includes an evaluation of propeller design factors of larger diameter and considerable blade camber and width to obtain high static thrust.

WATER-BORNE AIRCRAFT

INVESTIGATION OF HIGH LENGTH/BEAM RATIO SEAPLANE HULLS WITH HIGH BEAM LOADINGS: HYDRODYNAMIC STABILITY. I---TECHNIQUES AND PRESENTATION OF RESULTS OF MODEL TESTS. Appendix I---MODEL HULL DESIGN II---THE EFFECT OF CHANGES IN THE MASS, MOMENT OF INERTIA AND RADIUS OF GYRATION ON LONGITUDINAL STABILITY LIMITS. D.M. Ridland, J.K. Friswell, and A. Kurn. VI---THE EFFECT OF FOREBODY WARP ON STABILITY AND SPRAY CHARACTERISTICS. X---THE EFFECT OF AFTERBODY LENGTH ON STABILITY AND SPRAY CHARACTERISTICS. XXI---SOME NOTES ON THE EFFECT OF WAVES ON LONGITUDINAL STABILITY CHARACTERISTICS. D.M. Ridland. Gt. Brit., ARC CP 201, CP 202, CP 203, CP 204; MAEE Rep. F/Res/257, 1955. 50, 34, 34, 35, 58 pp. 79 refs. Detailed analytical survey of aerodynamic and hydrodynamic test results of stability, resistance, and impact factors from RAE Seaplane Towing Tank experiments on dynamic models with varied afterbody length (the distance from main step to rear step measured parallel to hull datum), zero flap, and no slipstream to determine the effects of forebody warp, angle and shape, spray characteristics, longitudinal and directional stability, and the step fairing on the overall disturbed and undisturbed stability in terms of limits of undisturbed criteria; includes statistical correlations for wake deformations and disturbances, elevator effectiveness at varied hull parameters, and a comparison to theoretical predictions.

STRUCTURAL BEHAVIOR OF SEAPLANE HULL BOTTOM PLATING. Appendix A---ANALYSIS OF HULL BOTTOM PLATING BY THE MOMENT-AREA METHOD. Appendix B---COMPARISON OF ASTM COUPON TEST WITH SPECIMEN OF 75S-T6 TENSION FIBER STRESSES OBTAINED FROM STRAINS MEASURED AT THE MIDDLE OF THE PLATE SPAN. J.W. Cox. IAS 24th Annual Meeting, New York, Jan. 23--26, 1956, Preprint 586. 21 pp. Members, $0.65; nonmembers, $1.00. Results of the three-phase Martin experimental investigation covering the strain distribution and fatigue life under cyclic pressure loading, taking into account the parameters of span-thickness ratio and elastic edge spring constant, using a Sonntag machine in the testing of small specimens to establish scatter limits on an S-N diagram of plating fatigue failures with the test stresses carried out over the range of expected plate working stresses and a model panel simulating typical construction.



N. T. Avant, aerodynamicist (left), R. R. Heppe, Aerodynamic Department head (center), and C. F. Branson, aerodynamicist, discuss wind tunnel tests to determine transition height of a supersonic superiority fighter.

Hovering to High Speed Flight:

Lockheed Aerodynamics Projects Offer Advanced Problems

Aerodynamics Engineers at Lockheed are working on advanced problems that cover virtually every phase of aircraft. The full scope of their work can be seen in the wide range of aerodynamics problems encountered in Lockheed's diversified development program.

Among the advanced problems are:

1. Determine means of controlling a supersonic vertical rising aircraft through the transition flight stages from horizontal to vertical flight.
2. Determine the dynamic response of supersonic aircraft in high rate rolls by application of five degrees of freedom analysis procedures.
3. Study optimum operating descent procedures to minimize costs on a new turboprop commercial aircraft.
4. Conduct and analyze wind tunnel research on new and radically different external radomes to be carried at high speed by early warning aircraft.
5. Perform generalized aeroelastic analysis combining structural and aerodynamic knowledge to determine optimum lateral control devices for use on very high speed, low load factor aircraft.

These—and many other—significant problems have created new positions for experienced Aerodynamics Engineers and Aerodynamicists in Lockheed's expanding program of diversified development.

You are invited to write E. W. Des Lauriers, Dept. A-5-2, for a brochure describing life and work at Lockheed in the San Fernando Valley and an application form.

Additional information on these problems and data on Lockheed's Aerodynamics Division is available to interested engineers. Address inquiries to R. R. Heppe.

LOCKHEED AIRCRAFT CORPORATION

CALIFORNIA DIVISION BURBANK **CALIFORNIA**

Computations in Aircraft Design. B. Langefors. *Saab Sonics*, No. 23, 1955, pp. 8–16, 25. Operational principles of automatic high-speed methods and apparatus providing for data processing, matrix analysis, and rational or tabular representation.

An Analog Computer for the Solution of Tangents. F. S. Preston. *IRE Trans., EC Ser.*, Sept., 1955, pp. 101–106.

The Design of a Basic Electric-Tank Analogy Installation. W. B. Brower, Jr., and P. DeRienzo. *Rensselaer Polytech. Inst. Dept. Aero. Eng. TR AE5505*, Sept. 1, 1955. 9 pp. USAF-sponsored development of mechanical and electrical analogical apparatus for use in two-dimensional flow studies.

An Electronic Analog Computing Technique for the Solution of Trigonometric Problems. A. S. Robinson. *IRE Trans., EC Ser.*, Sept., 1955, pp. 95–101. 10 refs.

Function Generation on the Differential Analyzer Extended to the Analog Computer. David F. Rearick. *Sperry Eng. Rev.*, Sept.-Oct., 1955, pp. 25–29.

High-Speed Electronic-Analogue Computing Techniques. D. M. MacKay. (*IEE Paper 1738 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 609–620; Discussion, pp. 620–623.

The Use of Electronic Analogue Computers with Resistance Network Analogues. W. J. Karplus. *Brit. J. Appl. Phys.*, Oct., 1955, pp. 356, 357.

Closed-Loop Control Systems Containing a Digital Computer. T. Teichmann. *IRE Trans., EC Ser.*, Sept., 1955, pp. 106–117. 11 refs. Analysis of the concepts of delay and distortion in feedback loops under digital control as related to the analog transfer function.

Digital Memory in Barrier-Grid Storage Tubes. M. E. Hines, M. Chruney, and J. A. McCarthy. *Bell System Tech. J.*, Nov., 1955, pp. 1,241–1,264. Design and operational characteristics applied to binary digital information storage.

A Nine's Complement Decade Counter and Recorder. J. A. Phillips. *Australia, ARL IN 55*, Apr., 1955. 22 pp. Design, operation, and potentialities of a binary circuit.

Electronics

Amplifiers

Distortion in Feedback Amplifiers. R. W. Ketchledge. *Bell Systems Tech. J.*, Nov., 1955, pp. 1,265–1,285. Analysis for the case where feedback magnitude and phase vary with frequency and the distortion products are small compared to the fundamentals, with the nonlinear elements described by a power series of a few terms.

On Distributed Amplification. D. G. Sarma. (*IEE Paper 1889 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 689–697. Staggering principles applied to improve response characteristics for such cases as a staggered distributed amplifier, an amplifier with constant-*k* *LC* filter network, an amplifier with *m*-derived *LC* filter network, and an amplifier with bridged-T all-pass sections in grid line and *m*-derived low-pass sections in anode line.

Antennas

Aircraft Antenna System Lightning Protection. R. F. Huber, M. M. Newman, and J. D. Robb. *IRE Trans., ANE Ser.*, Sept., 1955, pp. 19–23. Requirements of insulated aircraft wing or fin cap sections, with the development of an arrester design using a combination gap and series capacitor.

Circuits & Components

Electronics Design Influence on Aircraft Design. John R. Moore. *Aero Dig.*, Oct., 1955, pp. 62, 64. Application of the integrated systems concept to procurement of components.

Industrial Television; Aeronautical Applications of Closed-Circuit Television. *Aircraft Prod.*, Nov., 1955, pp. 452–455.

NBS-BUAER Preferred Circuits Program. *U.S., NBS Sum. TR 1958*, Oct., 1955. 6 pp. Standardization and simplifying techniques to develop operational reliability.

A New Circuit for Amplitude Comparison. M. C. Holtje. *Gen. Radio Exp.*, Nov., 1955. 6 pp.

Communications

Improving Air-Ground Communications. E. W. Pappenfus. *IRE Trans., ANE Ser.*, Sept., 1955, pp. 6–9. Analysis of network design requirements and of the relative merits of HF and VHF equipment.

Crystals

Ceramics for Piezoelectric Transducers. *U.S., NBS Sum. TR 1946*, Sept., 1955. 5 pp.

Dielectrics

Breakdown of Solid Dielectrics in Divergent Fields. J. H. Mason. (*IEE Monograph 127 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 725–727. 25 refs. Abridged.

Capacitor Materials with High Dielectric Constant. G. H. Jonker. *Philips Tech. Rev.*, Nov., 1955, pp. 129–137. 11 refs.

Field-Dependent Conductivity in Non-Uniform Fields and Its Relation to Electrical Breakdown. Patrick T. G. Flynn. (*IEE Monograph 128 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 723–725. 15 refs. Abridged.

Electronic Controls

Factors to Consider in Specifying Relays. James F. Rinke. *Mach. Des.*, Oct., 1955, pp. 160–170. Analysis of automatic and semiautomatic electromagnetic control components in terms of number and design of circuits, type of switching, actuation power, operational speeds, duty cycle, life expectancy, environmental conditions, physical requirements, and cost; applications include recorders and servomechanisms.

The Frequency-Response Analysis of Non-Linear Systems. P. E. W. Grensted. (*IEE Monograph 126 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 721–723. Abridged.

From Linear Mechanics to Nonlinear Mechanics. Julien Loeb. (*An. Télécomm.*, Paris, Feb., 1950, pp. 65–71.) *U.S., NACA TM 1396*, Oct., 1955. 18 pp. Translation. Application of telecommunication principles to the development of a method for the linearization of nonlinear electromechanical control devices in which a sweep function acts as a carrier wave in radio-electricity.

Electronic Tubes

Reflex Klystron for Grid Pulse Operation Within the Frequency Range 2000–5000 Mc/s. Lennart Torstensson. *Ericsson Tech.* (Stockholm), No. 2, 1954, pp. 297–308. Design, development, and performance factors; applications.

Some Experiments on the Breakdown of Heater-Cathode Insulation in Oxide-Cathode Receiving Valves. G. H. Metson, E. F. Rickard, and F. M. Hewlett (*IEE Paper 1857 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 678–683.

A Study of the Long-Term Emission Behaviour of an Oxide-Cathode Valve. G. H. Metson. (*IEE Paper 1790 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 657–675; Discussion, pp. 675–677.

Magnetic Devices

The Behavior of Ferrites at Microwave Frequencies. Bobby J. Duncan and Leonard Swern. *Sperry Eng. Rev.*, Sept.-Oct., 1955, pp. 19–24. Theoretical principles and fundamental characteristics.

A Logical Reading System for Non-return-to-Zero Magnetic Recording. A. S. Hoagland. *IRE Trans., EC Ser.*, Sept., 1955, pp. 93–95.

Measurements & Testing

Residual Effects in the Campbell Bridge Method for the Absolute Measurement of Resistance, and a Note on a New Bridge. N. F. Astbury. (*IEE Monograph 130 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 729, 730. Abridged.

Navigation Aids

Long Range Telecommunications—Navaids—Dectra and Delrac Systems. L. Arthur. *The Log*, Nov., 1955, pp. 285–289. Design and operational factors, including accuracy and range, reliability, noise suppression, and information display.

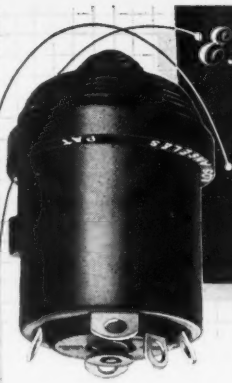
A Miniature Airborne Pictorial Plotter. S. Romano. *IRE Trans., ANE Ser.*, Sept., 1955, pp. 23–25. Development of the instrument panel-mounted Fighter Situation Display to evaluate the geographic position, with installation factors.

The RΘ-DR Computer System. W. F. Haehnel and J. L. McKelvie. *Can. Aero. J.*, Nov., 1955, pp. 183–191. Design and operational principles of the automatic ground-position computer developed by PSC Applied Research Ltd. for high-speed, all-weather navigation during patrol and interception flights.

Networks

The Correlation Between Decay Time and Amplitude Response. S. Demczynski. (*IEE Monograph 139 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 731, 732. Abridged. Application to network design.

The Graphs of Active Networks. W. S. Percival. (*IEE Monograph 129 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 727–729. Abridged.



Exceptionally
SAFE, RELIABLE 4-THROW SWITCH

MASON 446101 Series —heavy duty, momentary contact

Rated at 20 Amps. inductive at 30VDC at 60,000 feet. Approvals: MIL-S-9419; QPL-9419. Over 30,000 in use operating aircraft trim actuators safely.

Massive wiping contacts on these switches withstand tremendous overloads. Fast make and break reduces arcing time. High contact pressure prevents welding. The positive action makes contacts engage and disengage with absolute finality.

Directs actuation of trim, hoist and seat motors. Many other uses. Suitable for industry at normal commercial voltages.

Write for literature

MASON

MASON ELECTRIC CORP.
3839 Verdugo Rd., Los Angeles 65, Calif.
SWITCHES DESIGNED FOR RELIABILITY

A COMPLETE MEDIA PACKAGE
FOR YOUR
Aviation Marketing Program

AERONAUTICAL ENGINEERING REVIEW

For your monthly advertising message to the aircraft industry's engineering and design personnel—the men who influence buying.

1956
MEDIA
DATA
FILE
Available!

12 pages of FACTS on your market and REVIEW.

Write for free copy TODAY!

AERONAUTICAL ENGINEERING CATALOG

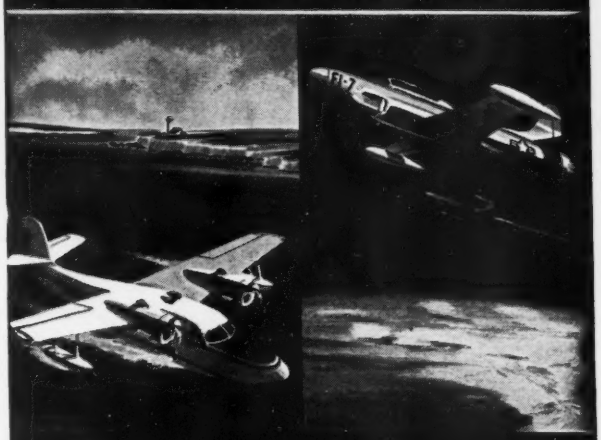
Prefiles and distributes your aircraft products catalog to aviation's buyers and specifiers.

7,000 copies are distributed annually to aircraft engineers, designers, technicians and purchasing agents in all leading aircraft, engine and parts companies, Government aviation departments and leading air lines.

Write for your free copy of 8-page Booklet giving full details.

OFFICIAL PUBLICATIONS
INSTITUTE OF THE AERONAUTICAL SCIENCES
2 East 64th Street New York 21, N.Y.

From Water Level To Stratosphere...



Pittsburgh FABSEAL

Makes Flying Safer... More Efficient!

Millions of flying hours prove the dependable performance of these impregnated fabric tapes in civilian and military use!

● Many of America's leading builders of aircraft use Pittsburgh's FABSEAL Tapes with complete confidence in their outstanding quality to seal flying boats, pressurized cabins and for other applications where there is considerable racking movement.

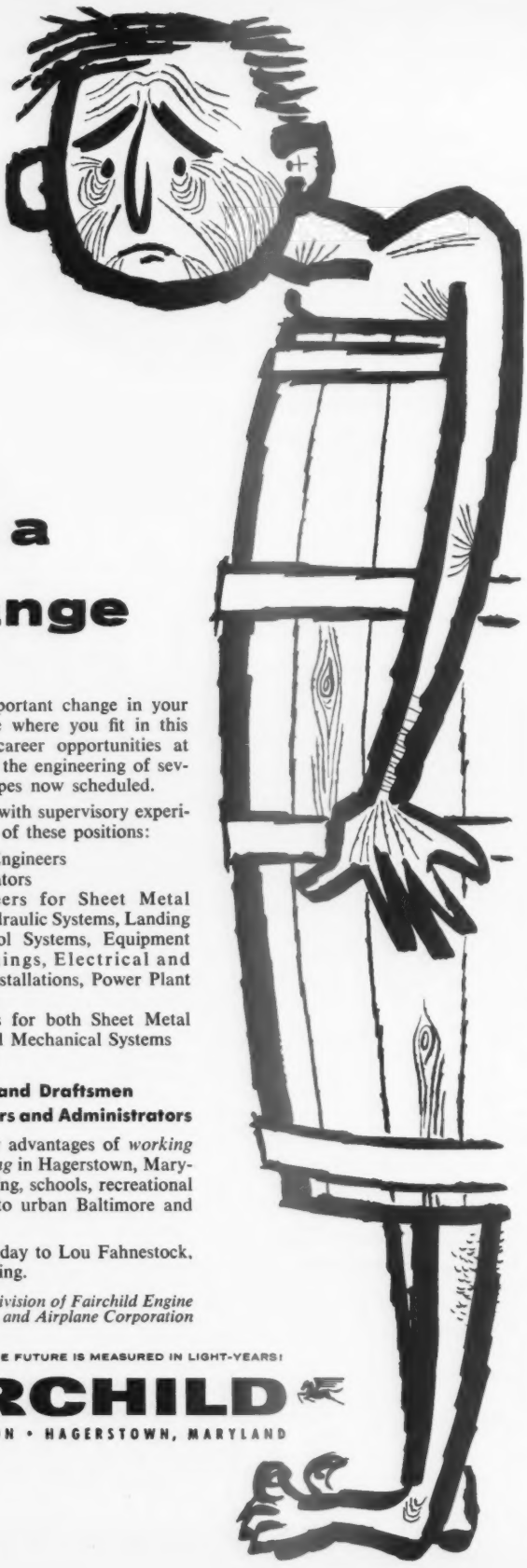
● FABSEAL Tapes are impregnated fabric of uniform density, resistant to water, gasoline and oil. They are available in .015″ thickness and in widths from ½″ to 12″, packages in rolls of 50 feet.

● These tapes are particularly designed for use in fluid or air containers where excessive pressures are experienced. They are also adapted for sealing structural members where flexibility and vibration present unusual requirements. FABSEAL Tapes can also be bolted, riveted or screwed between metal, wood or fiber members to provide a fillet that assures a complete seal.

● Call on us for advisory service. Our wide experience in the aircraft field often can save you time and money.

PITTSBURGH PLATE GLASS CO., Industrial Paint Div., Pittsburgh, Pa. Factories: Milwaukee, Wis.; Newark, N. J.; Springdale, Pa.; Houston, Texas, Los Angeles, Calif.; Portland, Ore. Ditzler Color Div., Detroit, Michigan. The Thresher Paint & Varnish Co., Dayton, Ohio. Forbes Finishes Division, Cleveland, Ohio. M. B. Suydam Div., Pittsburgh, Pa.

PPG **PITTSBURGH PAINTS**
PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS • FIBER GLASS
PITTSBURGH PLATE GLASS COMPANY



time for a change

Bring about that important change in your working climate. See where you fit in this list of outstanding career opportunities at Fairchild to assist in the engineering of several airplane prototypes now scheduled.

Aircraft Engineers with supervisory experience in one or more of these positions:

- Design Project Engineers
- Design Coordinators
- Design Engineers for Sheet Metal Structure, Hydraulic Systems, Landing Gears, Control Systems, Equipment and Furnishings, Electrical and Electronics Installations, Power Plant Installations
- Stress Engineers for both Sheet Metal Structures and Mechanical Systems
- Weight Control

Layout Designers and Draftsmen

Project Coordinators and Administrators

Investigate the many advantages of *working* at Fairchild, and *living* in Hagerstown, Maryland—excellent housing, schools, recreational facilities . . . close to urban Baltimore and Washington.

Send your resume today to Lou Fahnestock, Director of Engineering.

A Division of Fairchild Engine and Airplane Corporation

. . . WHERE THE FUTURE IS MEASURED IN LIGHT-YEARS!

FAIRCHILD

AIRCRAFT DIVISION • HAGERSTOWN, MARYLAND

Oscillators & Signal Generators

Cathode-Follower Phase-Shift Oscillator. J. C. Samuels. *Elec. Commun.*, Sept., 1955, pp. 198–202. Derivation of the frequency of oscillation and the necessary gain for sustained oscillation for three designs, with experimental models.

The Design of a Wide-Band Low-Audio Frequency Oscillator. G. W. Holbrook. *Eng. J.*, Nov., 1955, pp. 1,515–1,519.

Semiconductors

The Field Effect Transistor. G. C. Dacey and I. M. Ross. *Bell System Tech. J.*, Nov., 1955, pp. 1,149–1,189. Theoretical and experimental study of design, operational, and fabricational factors; applications.

Transmission Lines

Direct-Coupled Waveguide Filters. Henry Scheftelowitz. *Ericsson Tech.* (Stockholm), No. 2, 1954, pp. 253–296. 15 refs. Applications of three design methods, with experimental data and circuit details, taking into account use of filters under mismatched conditions.

The Theory and Design of Coaxial Resistor Mounts for the Frequency Band 0–4000 Mc/s. I. A. Harris. (*IEE Monograph 132 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 730, 731. Abridged.

Theory of Imperfect Waveguides: The Effect of Wall Impedance. A. E. Karbowiak. (*IEE Paper 1841 R.*) *Proc. IEE Part B*, Sept., 1955, pp. 698–708.

Wave Propagation

The Night-Time Lower Ionosphere as Deduced from a Theoretical and Experimental Investigation of Coupling Phenomena at 150 kc/sec. R. W. Parkinson. *J. Atmospheric & Terrestrial Phys.*, Oct., 1955, pp. 203–234. 27 refs. USAF-sponsored study.

Wave Solutions for Critical and Near-Critical Coupling Conditions in the Ionosphere. N. Davids and R. W. Parkinson. *J. Atmospheric & Terrestrial Phys.*, Oct., 1955, pp. 173–202. 15 refs. USAF-sponsored research.

Equipment

Electric

Basic Design Considerations for Electrical Temperature Control. Douglas T. King. *Mach. Des.*, Oct., 1955, pp. 189–200.

On the Theory of a Two-Stage A-C. Rotary Amplifier. E. Mishkin. *J. Franklin Inst.*, Nov., 1955, pp. 357–372. Design characteristics and operational principles; applications.

The Performance of Helical Membrane Co-Axial Cable in the Frequency Range Above 1000 Mc/s (Über das Verhalten Koaxialer Kabel mit Bandwendelisolierung im Frequenzbereich über Tausend Megahertz). H. Kaden. (*Arch. für Elektrotech.*, Berlin, 1953, pp. 45–64.) *Gt. Brit., RAE Lib. Transl. 528*, Sept., 1955. 32 pp.

Signal Pickoffs. Donald A. Davies. *Sperry Eng. Rev.*, Sept.-Oct., 1955, pp. 11–18. 16 refs. Operating principles, design characteristics, and relative merits

Aerodynamicists...

...we are proud of this Airplane!

CHANCE VOUGHT CRUSADER F8U-1
"World's Fastest Navy Fighter"

With the "CRUSADER" Chance Vought talent and teamwork has not only advanced the state-of-the-art but has done so with a truly practical and versatile airplane.

Senior Aerodynamicists who desire to join this winning team will discharge major aerodynamic responsibilities in the continued development of the "Crusader" and the "Regulus" guided missile and in preliminary design of other completely new aircraft and missiles.

Positions are available with very broad to highly specialized responsibilities.

We also have positions at *all* levels for theoretical aerodynamicists and operations analysts as well as openings for aerodynamicists with one and two years of general aerodynamics experience.

Joining our fine engineering team will offer:

- **Professional Advancement**
- **Individual Recognition**
- **Lower Cost of Living**
- **Interesting Projects**
- **Excellent Housing and Schools**
- **Paid Advanced Education**

Full company benefits include generous relocation allowances to Dallas, where we feel a real sense of personal freedom in our clean and uncrowded surroundings.

To arrange for a personal interview and a confidential evaluation of your qualifications send a resumé of your background to: ENGINEERING PERSONNEL

CHANCE VOUGHT AIRCRAFT
INCORPORATED

P. O. BOX 5907 • DALLAS, TEXAS

of electric inductive and photoelectric types.

Hydraulic & Pneumatic

Applying Fixed-Displacement Pumps to Variable-Pressure Hydraulic Servomechanisms. Sherman Z. Dushkes. *Mach. Des.*, Oct., 1955, pp. 171–175. Design analysis of internal and external bypassing systems to effect reduced size, weight, and costs in the multihorsepower range.

Design Manual: Adjustable-Speed Hydraulic Drives. Keith A. Carlson. *Mach. Des.*, Oct., 1955, pp. 214–232. Graphical analysis of stepped and stepless types in terms of the factors of speed and torque ranges, power output, control systems, reversing methods, size and weight, reliability, and environmental conditions using positive-displacement pumps and motors as basic components; applications.

The Effect of Oil-Column Acoustic Resonance on Hydraulic Valve "Squeal." F. W. Ainsworth. *ASME Diamond Jubilee Semi-Annual Meeting, Boston, June 19–23, 1955, Paper 55-Sa-14.* 5 pp. Methods to eliminate oscillation, with results of stability tests.

Measuring Performance of Hydraulic Machines. H. Stern. *Prod. Eng.*, Nov., 1955, pp. 150–155. Comparison of thermocouple and thermistor methods to measure precisely rapid changes of temperatures of the fluid in the determination of input and output efficiency under conditions of high speed or in the case of inaccessible shafts.

Piston Rings for Hydraulics. Ernest J. Taschenberg and John W. Pennington. *Appl. Hydraulics*, Nov., 1955, pp. 67–70, 120. Design and development of metallic sealing rings, taking into account dimensions and finishes of the hydraulic cylinders and pistons.

Fuels & Lubricants

Equilibrium Performance Calculations for Ethylene Oxide as a Monopropellant—Including the Effects of the Solid Phase. D. M. Meehan and Seba Eldridge. *Jet Propulsion*, Oct., 1955, pp. 544, 545.

Experimental Flame Temperatures of an Ammonium Perchlorate Solid Propellant. George S. Sutherland, Dwight A. Mahaffy, and Martin Summerfield. *Jet Propulsion*, Oct., 1955, pp. 537–539.

Fuels for Rockets. E. A. Smith. *Aeronautics*, Nov., 1955, pp. 26–28. Comparative study of basic properties and potentialities of turbojet, ramjet, and rocket fuels in terms of operational and applicational requirements.

Gliders

The Low Drag Sailplane, Tiny Mite, Modification 1954. August Raspet and Raymon Parker. *J. Aero. Soc. India*, Aug., 1955, pp. 47–54. Design and performance characteristics, with an aerodynamic analysis of boundary-layer control features.

Ice Formation & Prevention

The Atomisation of Water by Air Blast Nozzles for the Simulation of Cloud Conditions for Icing Research. Appendix I—Quantity of Water to be Atomised by a Nozzle. Appendix II—Theoretical Performance of the Napier 0.018″ Nozzle. F. J. Vigg. *Gt. Brit., RAE TN Mech. Eng. 203*, June, 1955. 24 pp. 10 refs.

Development and Test of a Cooled Rotating Disc Icing Meter. Appendix I—The Thickness of Ice Formed on a Rotating Disc. F. J. Bigg. *Gt. Brit., RAE TN Mech. Eng. 200*, Mar., 1955. 21 pp.

Impingement of Water Droplets on NACA 65A004 Airfoil at 0° Angle of Attack. Rinaldo J. Brun and Dorothea E. Vogt. *U.S., NACA TN 3586*, Nov., 1955. 28 pp.

Instruments

Automatic Control

The Adjustment of Control Systems for Quick Transient Response. A. T. Fuller. (*IEE Paper 1878 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 596–601. 13 refs.

Combining the Automatic Pilot and the Flight Director. E. H. Fritze and J. D. Rector. *IRE Trans., ANE Ser.*, Sept., 1955, pp. 15–19. Development, operational principles, and relative merits of the combined system, taking into account the function of the human pilot.

Graphical Aids for Frequency Response Analysis. Homer D. Eckhardt. *J. Aero. Sci.*, Jan., 1956, pp. 83–86. Use of a template for the direct construction or modification of "gain-phase" plots to determine the behavior of closed-loop dynamic systems such as servomechanisms.

Les Idées Fondamentales de la Théorie des Servomécanismes. H. Le Boiteux and R. Moreau. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 47–54. In French. Fundamental theoretical principles and characteristics of servomechanisms.

The Integral-of-Error-Squared Criterion for Servo Mechanisms. H. H. Rosenbrock. (*IEE Paper 1865 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 602–607.

The Mechanism of Sub-Harmonic Generation in a Feedback System. John C. West and John L. Douce. (*IEE Paper 1693 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 569–574. 10 refs. Application to servo and other automatic controls.

The Response of Remote-Position-Control Systems with Hard-Spring Non-Linear Characteristics to Step-Function and Random Inputs. John C. West and P. N. Nikiforuk. (*IEE Paper 1728 M.*) *Proc. IEE, Part B*, Sept., 1955, pp. 575–593; Discussion, pp. 594, 595. 20 refs.

A Survey of Some Recent Developments in the Automatic Control Field. John A. Hrones. *Appl. Mech. Rev.*, Dec., 1955, pp. 501–504. 10 refs. Application of feedback principles to the design of high performance servos and other control devices, taking into account system parameters, moment of inertia, damping ratio, reference input, and transient or disturbance response.

Trends in Autopilot Developments. William P. Lear. *Aero. Eng. Rev.*, Jan., 1956, pp. 26–33. Means to obtain optimum matching of men and machine analyzed in terms of automatic versus manual control requirements, as applied to the design of the Lear L-10.

Flight Instruments

Flight Calibration of Four Airspeed Systems on a Swept-Wing Airplane at Mach Numbers up to 1.04 by the NACA Radar-Phototheodolite Method. Jim Rogers Thompson, Richard S. Bray, and George E. Cooper. (*U.S., NACA RM A50H24*, 1950.) *U.S., NACA TN 3526*, Nov., 1955. 41 pp.

Flow Measuring Devices

A Three-Dimensional Spherical Pitot Probe. James E. Ash and John C. Lee. *ASME Diamond Jubilee Semi-Annual Meeting, Boston, June 19–23, 1955, Paper 55-SA-56.* 9 pp. Development to measure static pressure, magnitude, and direction of the velocity vector from any arbitrary flow angle.

Gyroscopes

Fundamentals of the Vibratory-Rate Gyro. J. B. Chatterton. *ASME Diamond Jubilee Spring Meeting, Baltimore, Apr. 18–22, 1955, Paper 55-S-25.* 9 pp. Review of operational principles and design characteristics, including developed torque, output sensitivity, and frequency response.

Symmetrical Aircraft Gyroscope Motor for Optimum Performance. H. C. Wendt. *ASME Diamond Jubilee Spring Meeting, Baltimore, Apr. 18–21, 1955, Paper 55-S-26.* 9 pp. Design and development covering such factors as high angular momentum to weight ratio, temperature range, size, shock and vibration resistance, power output, performance efficiency, and operational reliability.

Pressure Measuring Devices

Engine Pressure Indicators: Applications of the Balanced-Diaphragm Type. Gerald M. Rassweiler, John W. Leggat, Warren H. Smith, and John D. Caplan. *ISA J.*, July, 1955, pp. 247–250.

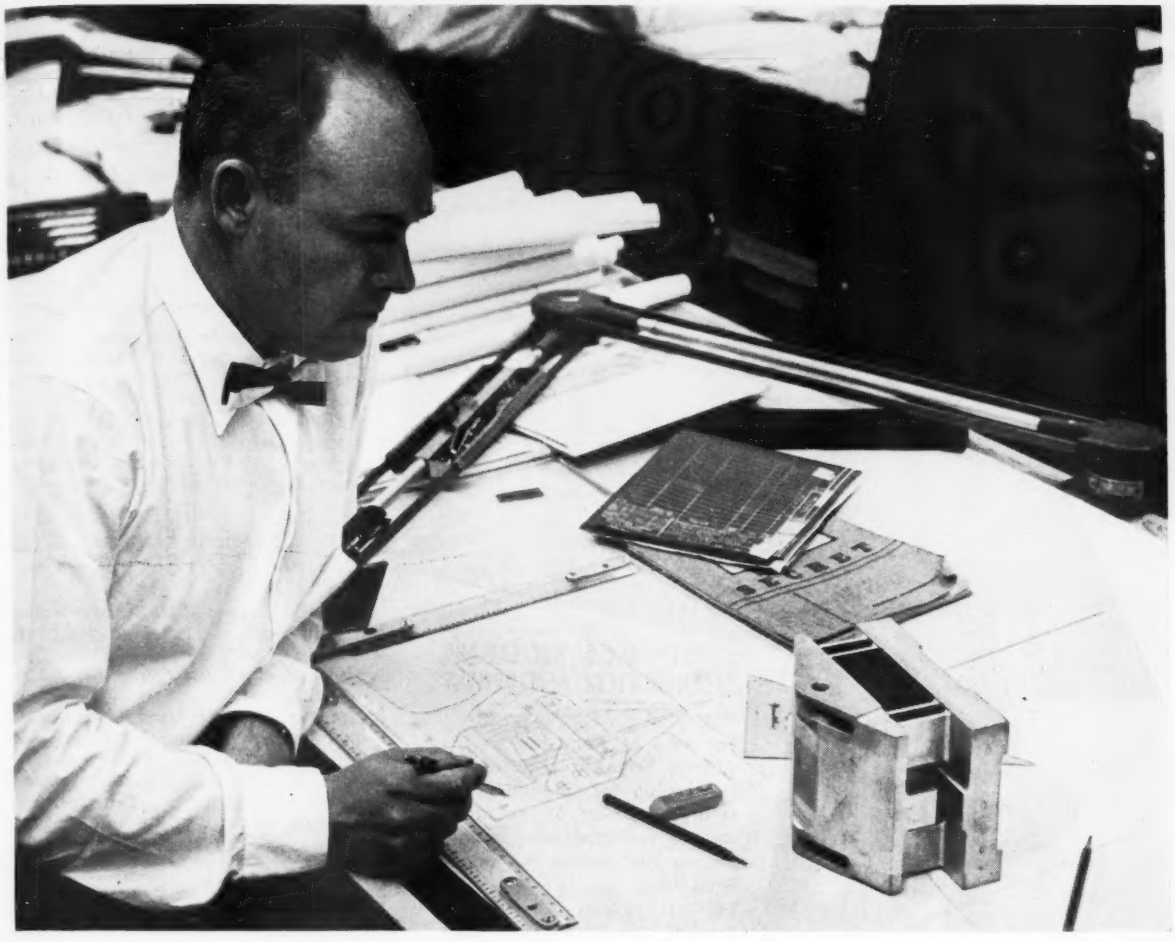
Engine Pressure Indicators: Applications of A Capacitor-Type. John W. Leggat, Gerald M. Rassweiler, and Yro T. Sihvonen. *ISA J.*, Aug., 1955, pp. 291–294. Continuous-indicating designs as applied to measurements of internal combustion, detonation, and explosions.

Engine Pressure Indicators: Associated Equipment for the Balanced Diaphragm Transducer. E. F. Weller, J. W. Leggat and R. V. Fisher. *ISA J.*, Oct., 1955, pp. 458–461. Design of components for quantitative diagrammatic pressure-versus-crankangle analyses of engine cylinders.

Engine Pressure Indicators: Recent Developments in Balanced-Diaphragm Pressure Transducers. L. R. Voss, L. E. Baker, E. F. Weller, and G. M. Rassweiler. *ISA J.*, Sept., 1955, pp. 348–351. Analysis includes design features, test methods and equipment, reproducibility, inherent lag, endurance, temperature effects, and malfunctioning factors.

Recording Devices

Characteristics of Oscillatory Mass Instruments. A. K. Jenkins. *The Engr.*, Nov. 18, 1955, pp. 716–720. Analysis of basic principles obtaining general response solutions from data of damped oscillatory-mass devices for a variety of impressed



Thrust gage design is this Boeing engineer's "baby"

From layout to actual missile firing, this project is a Boeing aeronautical engineer's responsibility. His assignment: to design an engine mount that will isolate from other loads and measure within ½ of 1% accuracy the tremendous in-flight thrust of a guided missile.

The mount, called a thrust gage, must fit engine and airframe without modification of them, and must "grow" equally in all directions during a temperature rise of several hundred degrees in less than a minute. The object: a stronger mount weighing less than half the present one.

This is typical of the challenging and creative assignments given Boeing aeronautical engineers. More of them are needed for responsible positions on years-ahead Boeing projects involving structural and flight testing, vibration, flutter, plasticity, elasticity and other specialties.

This engineer is finishing his layout, with the preliminary mockup before him. Next, he will supervise draftsmen and engineering aides in final drawings. Then he will work closely with other engineers in production, structural testing, instrumentation and telemetering. Creating this thrust gage gives him responsibility, career growth, and a real sense of professional achievement.

Boeing engineers have career stability in a soundly growing company that now employs more than twice as many engineers than at the peak of World War II. Living is pleasant for them in the progressive, comfortable-size communities of Seattle and Wichita.

These men take satisfaction in knowing they're on a winning team that has created such aviation milestones as the new 707 jet tanker-transport, the giant B-52, and the Boeing B-47, "backbone" of Strategic Air Command. There's a rewarding job awaiting you now at Boeing in design, research or production.

JOHN C. SANDERS, Staff Engineer—Personnel
Boeing Airplane Co., Dept. A-48, Seattle 14, Wash.

R. J. B. HOFFMAN, Administrative Engineer
Boeing Airplane Co., Dept. A-48, Wichita, Kansas

If you want further information on the advantages of a career with Boeing, please send coupon to either of the above addresses.

Name_____

College(s)_____ Degree(s)___ Year(s)___

Address_____

City_____ Zone___ State_____

Telephone Number_____

BOEING

Aviation leadership since 1916

SEATTLE, WASHINGTON WICHITA, KANSAS

...IN THE AGE OF NUCLEAR AND THERMONUCLEAR DEVELOPMENT

Interested in it? So are we!

For here at world-famous Los Alamos Scientific Laboratory, responsible for unleashing the terrifying power of the atom, we are now pioneering in harnessing this power for beneficial uses.

There is exciting adventure in the application of nuclear and thermonuclear energy to weapons, power and propulsion.

Supporting these diverse activities here at Los Alamos are many challenging projects in basic physics, chemistry, metallurgy, mathematics and engineering.

Los Alamos needs men and women with imagination and research ability for permanent career positions. Interested? So are we!

Write us for an illustrated brochure describing the Laboratory, its delightful mountain location and its excellent housing and community facilities. Mail your request to

DIRECTOR OF PERSONNEL
DIVISION 500

LOS ALAMOS SCIENTIFIC LABORATORY IS NOW IN ITS 14TH YEAR OF OPERATION.

los alamos
scientific laboratory
OF THE UNIVERSITY OF CALIFORNIA
LOS ALAMOS, NEW MEXICO

motions and pressures in recording transient physical phenomena.

The Subjective Discrimination of Pitch and Amplitude Fluctuations in Recording Systems. A. Stott and P. E. Axon. (*IEE Paper 1874 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 643–656.

Stress & Strain Measuring Devices

Photoelectric Counter for Interference Fringes. *U.S., NBS Sum. TR 1950*, Aug., 1955. 4 pp. Application to strain-gage calibration.

Temperature Measuring Devices

A Two-Variable Computer for a Continuous Indicating and Recording Psychrometer. Henry Burlage, Jr. *ISA J.*, Aug., 1955, pp. 298–300. 15 refs. A three-dimensional design to give absolute relation between wet and dry bulb temperatures based on detection signals from resistance thermometers.

Machine Elements

Bearings

Design Guide: Ball-Bearing Screws. David A. Galonska. *Mach. Des.*, Oct., 1955, pp. 201–210. Basic types, operational principles, selection factors, and applications.

A Fast Growing Trend—Integral Seal Ball Bearings. Carter T. Bragdon and Michael T. Monich. *Prod. Eng.*, Nov., 1955, pp. 179–185. Evaluation of such design factors as types, materials, temperature and speed effects on life, relative efficiency, and equipment requirements.

Gears & Cams

Gear Differentials. I. G. W. Michalec. *Mach. Des.*, Oct., 1955, pp. 178–188. Basic motion analysis of design criteria; applications.

Transmission, Clutches, & Drives

Irrational Speed Ratios. J. T. Lester, Jr. *Mach. Des.*, Oct., 1955, pp. 233–237. Application of fundamental number theory to the design of drive systems.

Materials

On Related Pairs of Plane Elastic States. R. Hill. *J. Mech. & Phys. Solids*, Oct., 1955, pp. 1–9. 15 refs. Application of analogous results in steady quasi-static viscous flow to problems of deformation in an elastic solid.

Corrosion & Protective Coatings

Study of Die Wear by Means of Radio-Activated Surfaces. B. J. Jaoul. (*ASME Diamond Jubilee Semi-Annual Meeting, Boston, June 19–23, 1955, Paper.*) *Steel Processing*, Oct., 1955, pp. 636–644.

Metals & Alloys

A Dictionary of Metallurgy. XXXVIII-*Re-Ro*. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Nov., 1955, pp. 465–472.

De Invloed van Temperatuurverhoging tot Ongeveer 450° C op de Mechanische Eigenschappen van de Constructiematerialen: Aluminiumlegeringen, Roestvrij

TO THE FINE ENGINEERING MIND
SEEKING THE CHALLENGING PROJECTS IN

AERODYNAMICS

AERODYNAMIC ENGINEERS AND SCIENTISTS are urgently needed now at Convair in beautiful, sunny San Diego, California. Excellent career opportunities exist for junior and senior engineers for aerodynamics, performance and heat transfer analyses related to advanced projects in the supersonic Mach number range. A balanced background in experimental and theoretical aerodynamics is ideal for these positions. Analytical aerodynamic studies using analogue and digital computers are an integral part of this work. Challenging positions are also available for aerodynamicists experienced in research and development wind tunnel and firing range tests.

CONVAIR offers you an imaginative, explorative, energetic engineering department... truly the "engineer's" engineering department to challenge your mind, your skills, your abilities in solving the complex problems of vital, new, long-range programs. You will find salaries, facilities, engineering policies, educational opportunities and personal advantages excellent.

SMOG-FREE SAN DIEGO, lovely, sunny city on the coast of Southern California, offers you and your family a wonderful, new way of life ...a way of life judged by most as the Nation's finest for climate, natural beauty and easy (indoor-outdoor) living. Housing is plentiful and reasonable.

Generous travel allowances to engineers who are accepted. Write at once enclosing full resume to: H. T. BROOKS, ENGINEERING PERSONNEL DEPT. 514

CONVAIR

A Division of General Dynamics Corporation

3302 PACIFIC HIGHWAY · SAN DIEGO, CALIFORNIA

Staal, Titaan en Titaanlegeringen (The Influence of Elevated Temperatures up to 450° C on the Mechanical Properties of Aluminum Alloys, Stainless Steel, Titanium, and Titanium Alloys). A. Hartman. *Netherlands, NLL Rep. M.1987,* June 14, 1955. 86 pp. 92 refs. In Dutch. Review of the literature, with an analysis of material characteristics and potentialities for aircraft applications.

Jet and Rocket Applications of the "New" Metals. I. Gerald D. Johnson. *J. Space Flight,* Nov., 1955, pp. 1–4. Physical and mechanical properties of titanium, steel, and other alloys.

Metal Fatigue: A Bibliography of Unpublished Reports. *Gt. Brit., MOS TIB/BIB (U)/4,* Aug., 1955. 23 pp. 305 refs. Chronological arrangement covering properties of: aluminum, steel and iron, and other metals and alloys; sandwich construction; corrosion fatigue; tests on joints and fasteners; testing apparatus for aircraft and components.

Nimonic Alloys and Other Heat-Resistant Materials in Sheet Form. H. E. Lardge. *Metal Treatment,* Oct., 1955, pp. 445–448. Development of physical and mechanical properties for use in aircraft gas-turbine combustion and exhaust systems.

On the Contribution of Crystallographic Fibring to Hardening Under Uniaxial Straining Conditions. J. F. W. Bishop. *J. Mech. & Phys. Solids,* July, 1955, pp. 259–266. 14 refs.

On Unsymmetrical Extrusion in Plane Strain. A. P. Green. *J. Mech. & Phys. Solids,* Apr., 1955, pp. 189–196. Plasticine experiments under the simplifying assumptions of a nonhardening plastic-rigid material to reveal the character of the deformation in confirmation of theoretical bases.

The Origin of Slip Bands in Plastically Deformed Metal Surfaces (Zur Entstehung von Gleitlinien auf Plastisch Verformten Metalloberflächen). W. Spaeth. (*Metalloberfläche,* Munich, Nos. 8, 12, 1953, pp. 119–121, 177–183.) *Gt. Brit., MOS TIB/T4512,* Aug., 1955. 16 pp. 10 refs.

Peritectic Reactions in Ternary Metal Systems. A. Prince. *Metal Treatment,* Nov., 1955, pp. 485–489.

Theory of Dynamic Creep (K Teorii Dinamicheskoi Polzuchesti). A. A. Predvoditelev and B. A. Smirnov. (*Vestnik Moskovskogo U., Phys. Mat. Nat. Sci.,* No. 8, 1953.) *U.S., NACA TM 1330,* Sept., 1955. 12 pp. Translation. Analytical development based on the Becker after-effect calculations of the metallic creep deformation phenomena under dynamic loadings.

A Theory of the Tensile and Compressive Textures of Face-Centred Cubic Metals. J. F. W. Bishop. *J. Mech. & Phys. Solids,* Jan., 1955, pp. 130–142. 27 refs.

A Critical Survey of Brittle Failure in Carbon Plate Steel Structures Other Than Ships. M. E. Shank. *Natl. Acad. Sci. NRC Rep. SCC-65,* Dec. 1, 1953. 48 pp. 138 refs. Includes a comprehensive bibliography.

The Effect of Prestraining in Simple Tension and Biaxial Tension on Flow and Fracture Behaviour of a Low Carbon Deep-Drawing Steel Sheet. F. Garofalo and J. R. Low, Jr. *J. Mech. & Phys. Solids,* July, 1955, pp. 275–294. 30 refs.

Experiments on Brittle Fracture of Steel Plates. D. K. Felbeck and E. Orowan. *Welding J. Res. Suppl.,* Nov., 1955, pp. 570-s–575-s. 17 refs.

A Study of the Final Stages of the Austenite to Martensite Transformation in SAE 1050 Steel. Melvin R. Meyerson and Samuel J. Rosenberg. (*Res. Paper 2616.*) *U.S., NBS J. Res.,* Sept., 1955, pp. 177–181. 12 refs.

The Yield of Mild Steel Under Impact Loading. J. D. Campbell. *J. Mech. & Phys. Solids,* Oct., 1954, pp. 54–62. 10 refs.

Metals & Alloys, Nonferrous

Aluminum Alloys for Elevated Temperature Service. E. H. Dix, Jr. (*CAI-IAS Internatl. Meeting, Ottawa, Nov. 3, 4, 1955, Preprint 574.*) *Aero. Eng. Rev.,* Jan., 1956, pp. 40–48, 57. Physical and fabricational properties, with results of tests on 7075-T6, 2024-T4, 2014-T6, and other alloys.

Metallography of Aluminum and Its Alloys; Use of Electrolytic Polishing. I—Bibliography of Metallographic Applications of Electrolytic Polishing of Aluminum and Its Alloys. II—Description of Several Micrographic Techniques Using Electrolytic Polishing. III—Experimental Investigation Regarding Use of an Automatic Apparatus for Electrolytic Polishing. P. A. Jacquet. (*France, ONERA Pub. 51,* 1952.) *U.S., NACA TM 1384,* Nov., 1955. 49 pp. 48 refs. Translation.

Triaxial Plastic Stress-Strain Relations for an Aluminum Alloy 14S-T4. Joseph Marin and H. A. B. Wiseman. *J. Franklin Inst.,* Nov., 1955, pp. 397–409. OOR-sponsored investigation to determine the validity of theoretical principles of simple plastic flows using constant stress ratios.

General Design Principles with Magnesium. E. V. Schirmer. *Mag. of Magnesium,* Nov., 1955, pp. 2–7.

Nonmetallic Materials

Aircraft Glazing Materials: A Method for Evaluating the Shatter Resistance of Aircraft Canopy Materials. J. A. Kies. *U.S., NRL Memo. 237,* Nov., 1953. 12 pp.

Aircraft Glazing Materials: Resistance to Crack Propagation Glazing Materials. Joseph A. Kies and Herschel L. Smith. *U.S., NRL Memo. Rep. 372,* Oct., 1954. 22 pp.

Manufacture and Properties of Metal-to-Metal Laminates. J. J. Saunders and H. R. Merriman. *Aero Dig.,* Nov., 1955, pp. 52–54.

"Araldite" Epoxy Resins; Some Details of the Various Forms Now Available and of Their Uses. *Aero Res. TN Bull. 151,* July, 1955. 6 pp.

Fluage et Biréfringence Mécanique de Certaines Résines Organiques. B. Persoz and G. Grenier. *La Recherche Aéronautique,* May-June, 1955, pp. 35–40. In French. Experimental results on creep, double-refractory and other mechanical properties of certain organic resins, in terms of temperature and particular aircraft requirements utilizing combinations of plastic materials.

Kralastics. Eugene J. Trunk. *Prod. Eng.,* Nov., 1955, pp. 171–173. Physical and mechanical properties of a new series of thermoplastics featuring high strength, toughness, and resistance to heat and corrosion; applications.

On the Dualism in the Fracture Theory. Masakazu Higuchi. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.,* Mar., 1955, pp. 155–169. 15 refs. Theoretical and experimental analysis of the phenomenal behavior of the microstructure to formulate a concept of the dualistic strength property of plastics, with an extension applied to simple cases of loading of specimens.

The Physical Properties of "Teflon" Polytetrafluoroethylene. R. C. Doban, C. A. Sperati, and B. W. Sandt. *SPE J.,* Nov., 1955, pp. 17–21, 24. Analysis in terms of the characteristics of tensile, elongation, flexural, stiffness, and impact strength, hardness, compressive stress under deformation, deformation under load, heat-distortion temperature, coefficient of linear thermal expansion, thermal conductivity, specific heat, water absorption, flammability, specific gravity, and resistance to weathering.

Testing

A Determination of Plastic Stress-Strain Relations. B. B. Hundy and A. P. Green. *J. Mech. & Phys. Solids,* Oct., 1954, pp. 16–21. Experimental tests on copper, zinc, and stainless steel.

The Dynamic Straining of Metals Having Definite Yield Points. D. B. C. Taylor. *J. Mech. & Phys. Solids,* Oct., 1954, pp. 38–46. Test analysis of the strain rate during nonuniform yielding of metals under repeated dynamic loading in terms of a time-yield stress relationship.

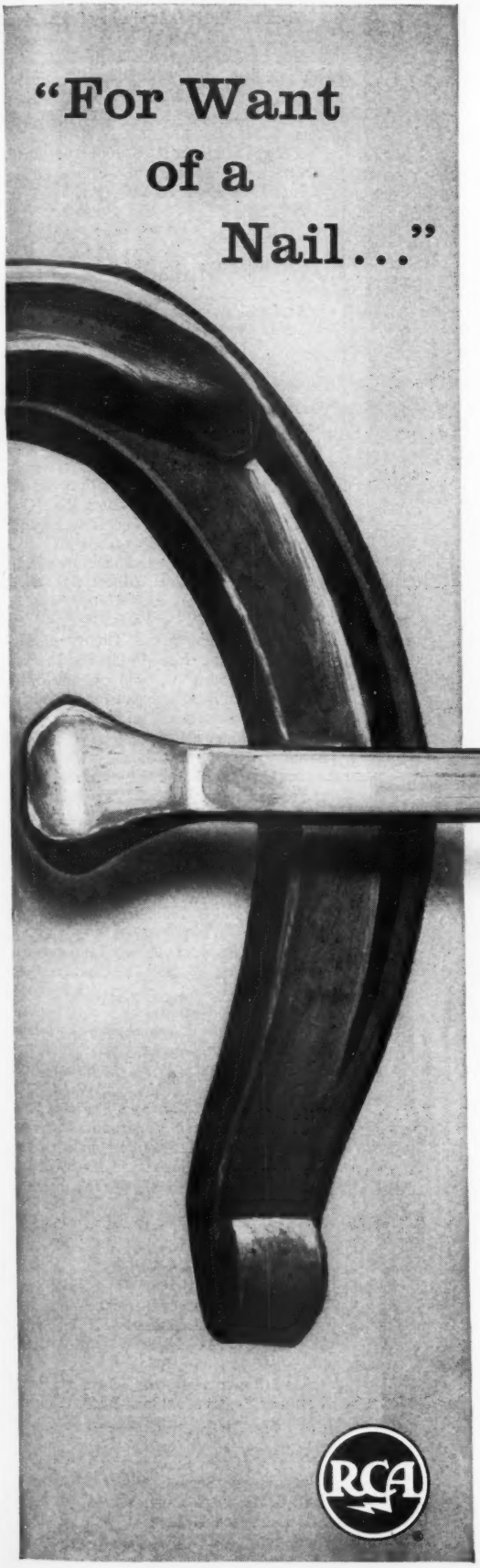
The Effect of Coulomb Friction in the Plane-Strain Compression of a Plastic-Rigid Material. J. M. Alexander. *J. Mech. & Phys. Solids,* July, 1955, pp. 233–245. Deformation tests to determine the yield strength of a metal strip under conditions similar to those found in the rolling process.

An Experimental Study of Biaxial Stress-Strain Relations in Plasticity. P. M. Naghdi and J. C. Rowley. *J. Mech. & Phys. Solids,* Oct., 1954, pp. 63–80. 12 refs. Experimental variable-loading path tests on ten tubular 24 S-T4 aluminum-alloy specimens with severe initial anisotropy to determine the initial shear modulus when twist began.

Experiments with Pyramidal Indenters. I, II. D. S. Dugdale. *J. Mech. & Phys. Solids,* Apr., 1955, pp. 197–211. Deformation tests on cold-drawn and manganese steels, cold-rolled and annealed copper, and silicon-aluminum.

Investigation of Fractures in Sintered Materials with the Electron Microscope. H. Pfisterer. (*Siemens Z.,* Berlin, May, 1955, pp. 199–205.) *Engr. Dig.,* Sept., 1955, pp. 425–428.

Ultra-High Strength Steels. G. Meikle. *Gt. Brit., RAE TN Met. 221,* May, 1955. 8 pp. Brown-Firth, Fairey, and RAE tests on steels of over 100 tons per sq.in. U.T.S.



For want of a nail the shoe is lost,
for want of a shoe the horse is lost,
for want of a horse the rider is lost.

George Herbert's statement applies to electronics today as it did to riders three centuries ago. The point may be illustrated by considering a vital electronic unit made up of thousands of components. If the least of these components fails, the whole unit may fail—and with it a strategic military mission.

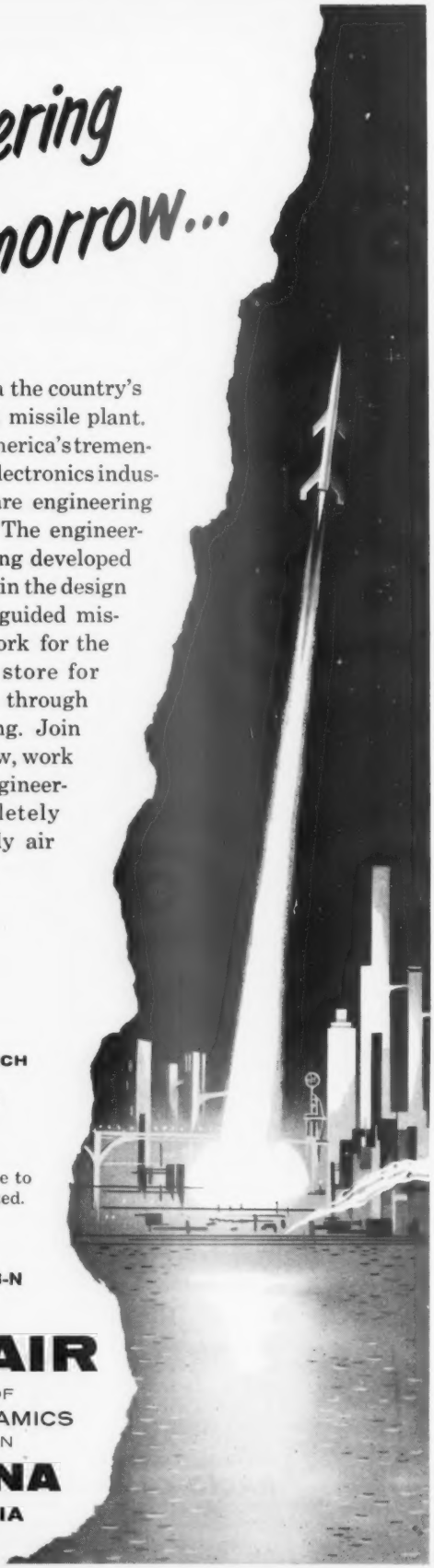
The problem of *reliability* is becoming increasingly important as the science of electronics advances. "Black boxes" are hard pressed to perform more complicated tasks with increasing efficiency. And at the same time, the requirements call for smaller dimensions. Notwithstanding environmental extremes of an order hitherto unknown, every resistor, capacitor and relay *must* perform *reliably*. Each "nail" is critical.

That is why RCA is continuing its vigorous search for ways and means to increase the reliability of every component in an electronic unit. This program never ceases. It follows through from design to field evaluation. Everything learned is immediately applied to current development and production.

In seeking a degree of electronic perfection never before attained, RCA joins hands with others in this field. This matter of *reliability* is an industry challenge to be met by ingenuity, brain power and engineering knowledge wherever it is found.

DEFENSE ELECTRONIC PRODUCTS
RADIO CORPORATION of AMERICA
CAMDEN, N.J.

Engineering for Tomorrow...



...at Convair-Pomona the country's first exclusive guided missile plant. Here in the heart of America's tremendously fast growing Electronics industry, we at Convair are engineering for tomorrow today! The engineering miracles now being developed for America's defense in the design and manufacture of guided missiles is the groundwork for the fantastic future in store for America tomorrow through electronic engineering. Join the Convair team now, work in America's finest engineering facility. Completely modern... Completely air conditioned.

Excellent opportunities now available in:

ELECTRONICS
AERODYNAMICS
DYNAMICS
THERMODYNAMICS
OPERATIONS RESEARCH
HYDRAULICS
MECHANICAL DESIGN
LABORATORY TEST
ENGINEERING

Generous travel allowance to Engineers who are accepted. Write now enclosing a complete resume to:

Employment Department 3-N

CONVAIR
A DIVISION OF
GENERAL DYNAMICS
CORPORATION
POMONA
CALIFORNIA

Vacuum Fusion Analysis of Titanium, Zirconium, and Molybdenum; Determination of Oxygen by the Iron Bath Technique. Robert S. McDonald John E. Fagel, Jr., and Earl W. Balis. *Anal. Chem.*, Oct., 1955, pp. 1,632–1,636. 14 refs.

X-Ray Microbeam Studies of Brittle Fractures of Metals. Lo-Ching Chang. *J. Mech. & Phys. Solids*, Apr., 1955, pp. 212–217.

Mathematics

Applications of the Rayleigh Ritz Method to Variational Problems. J. Indritz. *Pacific J. Math.*, Suppl. I, 1955, pp. 765–797. ONR-sponsored study.

Asymptotic Lower Bounds for the Fundamental Frequency of Convex Membranes. George E. Forsythe. *Pacific J. Math.*, Suppl. I, 1955, pp. 691–702. 13 refs. ONR-sponsored study.

The Computational Algorithm for the Parametric Objective Function. Saul Gass and Thomas Saaty. *Nav. Res. Logistics Quart.*, Mar.-June, 1955, pp. 38–45.

Fourier Analysis and Differentiation Over Real Separable Hilbert Space. F. H. Brownell. *Pacific J. Math.*, Suppl. I, 1955, pp. 649–662. 12 refs.

On a Problem in the Theory of Mechanical Quadratures. Philip Davis. *Pacific J. Math.*, Suppl. I, 1955, pp. 669–674.

On Certain Series Expansions Involving Whittaker Functions and Jacobi Polynomials. Peter Henrici. *Pacific J. Math.*, Suppl. I, 1955, pp. 725–744. 16 refs.

On Chains of Infinite Order. T. E. Harris. *Pacific J. Math.*, Suppl. I, 1955, pp. 707–724. 18 refs. USAF-supported research.

On the Convergence of Asymptotic Solutions of Linear Differential Equations. R. M. Redheffer and W. Wasow. *Pacific J. Math.*, Suppl. I, 1955, pp. 817–834. 14 refs.

On the Product of n Homogeneous Linear Forms. J. H. H. Chalk. *Proc. London Math. Soc.*, 3rd Ser., Oct., 1955, pp. 449–473. 15 refs.

Products of Inhomogeneous Linear Forms. H. Davenport and H. P. F. Swinnerton-Dyer. *Proc. London Math. Soc.*, 3rd Ser., Oct., 1955, pp. 474–499.

The Solution of Cauchy's Problem for a Third-Order Linear Hyperbolic Differential Equation by Means of Riesz Integrals. John G. Herriot. *Pacific J. Math.*, Suppl. I, 1955, pp. 745–763. ONR-sponsored research.

Meteorology

Further Studies of Hurricane Structure by Aircraft Reconnaissance. R. H. Simpson and L. G. Starrett. *Bul. AMS*, Nov., 1955, pp. 459–468.

Measurements of the Effect of Rain, Snow and Fogs on 8.6 mm Radar Echoes. N. P. Robinson. (*IEE Paper 1898 R.*) *Proc. IEE, Part B*, Sept., 1955, pp. 709–714. 18 refs.

Project Jet Stream Observation of a Small-Scale, High-Level Vortex. George S. McLean and Robert M. Rados. *Bul. AMS*, Nov., 1955, pp. 469–474. USAF B-47 synoptic flight observations.

ENGINEERS

NEW 2-FOLD RETIREMENT INCOME PLAN

for Aviation and Missile Engineers

It's natural that a long-time leader in aviation, like Republic—with many firsts to its credit—should be a leader, too, in providing for the welfare of its staff. Right in line with this forward-looking policy is the remarkable new Republic Retirement Income Plan. Here is how it works:

PART 1 *is a basic Retirement Income plan paid for* entirely *by Republic Aviation.*

PART 2 *is a cooperative effort. It is completely optional. But if an engineer wishes to increase his retirement fund, by making a small monthly payment, Republic will* MORE THAN MATCH *his contribution.*

Take the case of a hypothetical engineer who joins Republic on January 1st, 1956, averages $8,000 a year for 15 years; then retires aged 65. If he elected PART 2 of the plan, he will have a total *monthly retirement income of $225.80,* including his social security. For this he himself will contribute *only $8.50 a month* to the Republic Retirement Income Plan.

Of course, the MORE YOU EARN, the HIGHER your Retirement Income will be. And Republic pays a top salary scale in the industry.

...RETIREMENT PLAN JUST ONE OF MANY PLUS FACTORS POINTING TO A REPUBLIC CAREER

FIRST — there's the interest and prestige of working for a pioneer in aircraft design, creator of such famous planes as the F-84 Thunderjet, the F-84F Thunderstreak, RF-84F Thunderflash and XF-84H. (Soon to be followed on the production line by the new F-103, F-105 and RF-105.)

SECOND —the company is expanding sharply, providing frequent opportunities for able men to advance. In fact a $12,000,000 increase in the Research and Development Program has just been announced.

THIRD —an All-Expense Paid Relocation Plan for qualified engineers living outside the New York City and Long Island areas, which makes it easy to move to Republic. Other liberal benefits: Life, Accident and Health Insurance; Hospital-Surgical Benefits for the whole family; educational aid covering ⅗ the cost of collegiate and graduate study.

Serve your own best interests. Make full inquiries into the many advantages of joining Republic now, not the least of which is living on Long Island—the Playground of the East.

Important engineering positions are now open at all levels:

STAFF ENGINEERING	SYSTEMS	ELECTRO-MECHANICAL DESIGN	STRESS
PRELIMINARY DESIGN	MATHEMATICAL ANALYSES	FLIGHT TEST	AIRCRAFT DESIGN
ELECTRONICS	AERODYNAMICS	RESEARCH	WEIGHTS
WEAPONS SYSTEMS PROPOSALS	TECHNICAL WRITING	THERMODYNAMICS	DESIGNERS: Electrical Airframe Mechanical
OPERATIONS RESEARCH	DYNAMICS	FLUTTER & VIBRATIONS	

Please address complete resume outlining details of your technical background to:

REPUBLIC AVIATION

AIRCRAFT
Assistant Chief Engineer, Administration **Mr. R. L. Bortner,**
Farmingdale, Long Island, N. Y.

MISSILES
Administrative Engineer, Mr. Robert R. Reissig
Hicksville, Long Island, N. Y.

Radar and the Weather. Henry G. Houghton. *Tech. Rev.*, Nov., 1955, pp. 18–21. Development of a microwave technique for synoptic measurements of rain clouds, thunderstorms, and other atmospheric phenomena.

Missiles

History, Problems, and Status of Guided Missiles. George P. Sutton. *Jet Propulsion*, Nov., 1955, pp. 615–622. 18 refs. Developmental appraisal of American and foreign progress and design trends.

How to Design Guided Missile Control Systems; Prime Requirement: Right Balance Between Reliability and Complexity. George Reehl. *Av. Age*, Nov., 1955, pp. 24 (2 ff.). Appraisal of theoretical bases and operational requirements.

A Method for Estimating Altitude Performance of Balloon Launched Rockets. Malcolm S. Jones, Jr. *Jet Propulsion*, Oct., 1955, pp. 531–534. 10 refs. Analysis of the Van Allen-Gottlieb method in terms of preliminary data on 17 rounds of Deacon rockets fired from balloon altitudes during 1952 and 1953.

Presentation of the Proposed American Standard Letter Symbols for Rocket Propulsion. Robertson Youngquist and J. P. Layton. *Jet Propulsion*, Nov., 1955, pp. 634–645.

Navigation

Air Power and the Science of Aerial Navigation. Robert H. Terrill. *Navigation*, Sept., 1955, pp. 267–269. Appraisal of operational requirements and potentialities in terms of the basic factors of simplification and reliability.

Conditional Minimal Flight Paths. Irving I. Gringorten. *Navigation*, Sept., 1955, pp. 274–278. Procedure to yield a minimum of flying time under conditions of imposed aerial restrictions.

Inertial Navigation. J. M. Slater and D. B. Duncan. *Aero. Eng. Rev.*, Jan., 1956, pp. 49–52, 57. Appraisal of basic principles and limitations compared to celestial and dead-reckoning modes of navigation, with a method to determine vehicle position by acceleration and velocity measurements.

Polar Airline Navigation. Einar Sverre Pedersen. *Navigation*, Sept., 1955, pp. 270–274. Appraisal of requirements and potentialities covering personnel, techniques, and equipment, including: the training of navigators; polar charting and flight planning; grid-, astro-, and dead-reckoning navigation; and the use of magnetic compasses, gyros, radio aids, and Loran.

Photography

Les Appareils et Méthodes de Restitution Photogrammétrique Appliqués à l'Aérodynamique Expérimentale. P. Gréhant. *La Recherche Aéronautique*, May-June, 1955, pp. 14–21. In French. Application of photogrammetric methods and apparatus to experimental research into flow, vibration, trajectory, and other types of aerodynamic problems.

Microphotographie des Particules de Carburant Pulvérisé dans une Chambre de Combustion. R. Leboeuf and C. Véret. *La Recherche Aéronautique*, May-June, 1955, pp. 31–34. In French. High-speed microphotographic technique and apparatus to study complex combustion phenomena.

Optical Characteristics of Laminated Camera Windows. A. C. Marchant and B. M. Mathieson. *Gt. Brit., ARC CP 210*, 1955. 23 pp. 10 refs. BIS, New York. $0.65. Tests to develop criteria for shattering- and pressure-resistant requirements of higher air speeds.

Physics

Molecular Scattering and the Kinetic Theory of Gases. George Gioumousis. *U. Wis. NRL Dept. Chem. Rep. NSF-5*, Nov. 4, 1955. 49 refs.

Power Plants

Atomic

Nuclear Propulsion, Aviation's Future. D. G. Samaras. *Can. Aero. J.*, Nov., 1955, pp. 163–168. Developmental appraisal of various modes of propulsion using extra-nuclear and nuclear fuels to obtain maximum performance potentialities for visualized terrestrial, interplanetary, and intragalactic flight.

Jet & Turbine

Application of Some Systems Engineering Principles to the Design of a Fuel-Supply System. A. E. Buescher and G. J. Fiedler. (*ASME Diamond Jubilee Semi-Annual Meeting, June 19–23, 1955, Paper.*) *ISA J.*, Sept., 1955, pp. 352–360. Analysis of illustrative problems as developed for a test ramjet or turbojet engine facility.

Essai de Fatigue à Chaud en Traction Répétée ou Ondulée. G. Vidal and P. Lanusse. *La Recherche Aéronautique*, May-June, 1955, pp. 45–51. In French. Fatigue and tensile-strength tests and apparatus for turbine-blades subjected to a constant centrifugal and alternating symmetrical strain of a variable amplitude range under conditions of heat and repeated or wave-like traction.

The Fouling of Turbine Blading by the Products of Combustion of Pulverised Fuel. III—Simulation of the Fouling, Using an Inert Mineral. R. I. Hodge. *Gt. Brit., NGTE Memo. M.237*, Oct., 1955. 36 pp. 10 refs.

Heat Transfer Through Sweat Cooled Porous Tubes. H. L. Wheeler, Jr., and Pol Duwez. *Jet Propulsion*, Oct., 1955, pp. 519–524. AOD-sponsored investigation at the CIT Jet Propulsion Lab., with an interpretation of the results based on a simplified Rannie equation using hydrogen and nitrogen cooling gases, taking into account the pressure drop in an isothermal porous wall cylinder.

Mechanism of Convective Heat Transfer and Its Role in Gas Turbines. Appendix—Derivation of Curves for Mechanical and Volumetric Efficiency of Heat Exchangers. D. G. Wilson. *Chartered Mech. Engr.*, Nov., 1955, pp. 464–473. Fundamental boundary-layer principles of fluid mechanics applied to the analysis of different heat-exchanger designs in terms of requirements of turbine-blade cooling as estimated from the heat-transfer pattern round the surface of the blade.

Pulsating, Pressure Generating Combustion Systems for Gas Turbines. F. H. Reynst. *ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper 55-A-56.* 14 pp.

Designing a Control System for Jet Engine Environment Test Facility. Charles J. Stukas. *ISA J.*, June, 1955, pp. 184–186. Analysis using analog computational data and a 1/100 size model to determine static and dynamic conditions providing basic controls for ambient air temperature and pressure surrounding the engine and for engine inlet and exhaust oxygen conditions.

The Gyron Testbed; A Remarkable, New Facility for Testing Jet Engines of Enormous Power. *de Havilland Gazette*, Oct., 1955, pp. 134–139.

The 600 H.P. Overspeed and Bursting Rig at N.G.T.E., Pyestock. T. M. Jones and R. L. Brooking. *Gt. Brit. NGTE Memo. M. 249*, Sept., 1955. 10 pp. Design and installation features of the spinning rig for tests on gas-turbine components.

Ram-Jet & Pulse-Jet

Acoustic Analysis of Ram-Jet Buzz. Harold Mirels. *U.S., NACA TN 3574*, Nov., 1955. 33 pp. 13 refs. A one-dimensional analysis of the mechanism leading to buzz as the amplification of acoustic waves in the ram-jet combustion chamber due to successive reflections from the inlet and exit sections.

Studies of the Mechanism of Flame Stabilization by a Spectral Intensity Method. Richard R. John, Edward S. Wilson, and Martin Summerfield. *Jet Propulsion*, Oct., 1955, pp. 535–537. 17 refs. Experimental results applied to problems of ramjet-type combustion chambers.

Twenty-Five Years of Ramjet Development. William H. Avery. *Jet Propulsion*, Nov., 1955, pp. 604–614. 94 refs. NAVORD-sponsored analytical review of experimental and theoretical investigations of fundamental design problems, with a comprehensive bibliography.

Rocket

Manifolds for Solid-Propellant Rocket Motors. Richard D. Geckler. *Jet Propulsion*, Oct., 1955, pp. 540, 541. Development of a computational method to determine the required size of manifold connecting two similar rockets to reduce to any specified value the difference of the combustion-chamber pressure.

Rocket Motor Instability Studies. K. Berman and S. H. Cheney, Jr. *Jet Propulsion*, Oct., 1955, pp. 513–518. Low- and high-frequency instability tests using a window nozzle and Plexiglas insert, conventional, and throatless engine designs.

Twenty-Five Years of Rocket Development. Howard S. Seifert. *Jet Propulsion*, Nov., 1955, pp. 594–603. 71 refs. Evolutionary survey of experimental and theoretical investigations featuring gaseous-, liquid-, and solid-propellant and nuclear-powered engine designs.

Work where making engineering history is a habit...

and creative thinking is the way of doing it

positions now open at all levels
(Do not involve board work)

Aerodynamic Design and Analysis

Mechanical Development and Design

Controls and Accessories

Product Evaluation

Test Facilities Design

Manufacturing Engineers

Preliminary Design

When General Electric developed America's first jet engine, it was only the beginning of a long line of engineering "firsts" (and "mosts") destined to come from the department now known as the Aircraft Gas Turbine Division.

From that start came eventually the nation's most-produced jet engine, the J47, the powerplant backbone of the Air Force today, as well as the J73, J79 and other notable GE models. Advanced concepts in rocket engines are also developed and built in this GE department. Work on atomic aircraft engine applications is in progress.

The moving force behind these accomplishments has been the creative thinking of engineers who work in a stimulating atmosphere of freedom ... who are ready to take on new responsibilities as they arise ... who know the jet engine field from every aspect because they've worked on every aspect ... and who have confidence in what the future holds for them at GE.

There is room—and opportunity—for more men like them to take the jet field into more advanced stages and to advance their own careers as they do so. As much as opportunity, these openings also offer the outstanding advantages of association with GE—in terms of employee benefits, educational opportunities, stability and exceptional working conditions.

If this is the kind of environment, the kind of opportunity that interests you, why not learn more about these openings?

Please Write To:
MR. MARK PETERS
Technical Recruiting, Bldg. 100
Aircraft Gas Turbine Division

GENERAL ELECTRIC
CINCINNATI 15, OHIO

ENGINEERING SPECIALISTS

The Accessories Division of Thompson Products, Inc., offers you the opportunity to strengthen your technical foundation as you contribute to the progress of the Division.

The Following Positions Are Available:

FLUID MECHANICS
Turbines, Compressors and Pumps

COMBUSTION
Burners, Reaction Chambers and Gas Generators

SERVOMECHANISMS
Mechanical and Electrical

APPLIED MECHANICS
Stress Analysis, Vibration and Mechanisms

The Accessories Division is a leading manufacturer of aircraft accessories and products. You will have the chance to advance your career as you assist the Division to pioneer in aircraft systems and accessories. Your work will consist of preliminary analysis, problem studies, consultations and experimental research.

Proven ability, growth potential plus five to ten years' experience is required for these engineering specialist positions. Salaries commensurate with background and experience.

ALSO OPENINGS FOR DEVELOPMENT ENGINEERS AND DESIGN ENGINEERS

For project work on engine controls, booster pumps, gear pumps, and turbine power units.

Plant located in suburban Cleveland near beautiful residential areas.

Submit complete resume, including past earnings and availability for interviews in first letter to Vic Buescher (A.E.R.)

THOMPSON PRODUCTS, INC.
23555 Euclid Avenue **Cleveland 17, Ohio**

Production

Metalworking

Flame Hardening—Modern Methods and Equipment. I. John E. Hyler. *Steel Processing*, Oct., 1955, pp. 659–664, 668, 671.

High-Strength Light-Alloys; Some Notes on the Manipulation, Machining and General Handling of the Newer Materials. *Aircraft Prod.*, Nov., 1955, pp. 462–465.

Investigations and Studies on Metal Bonding Agents (Untersuchungen und Studien zum Metallkleben). G. Kaliske. (*Aluminium*, Düsseldorf, No. 4, 1955, pp. 151–156.) *Gt. Brit., RAE Lib. Transl. 552*, Oct., 1955. 15 pp. 30 refs. Basic principles of adhesion, bonding techniques, and requirements of bonded joints.

Development of a Die Block for Closed Die Forging. John A. Succop. *Steel Processing*, Oct., 1955, pp. 621–635. Abridged.

Extrusion Through Wedge-Shaped Dies. I, II. W. Johnson. *J. Mech. & Phys. Solids*, Apr., 1955, pp. 218–230.

Light Alloy Forgings for the Aircraft Industry; Review of Development During Last Decade. R. H. Daniels. *Metal Treatment*, Oct., 1955, pp. 421–424.

The Production of Large Light Alloy Forgings. II. A. W. Williams. *J. SLAE*, Oct., 1955, pp. 12–17. Survey of stock preparation, inspection, and process requirements.

Roll-Forming: Chipless Method of Producing Splines and Gear Teeth. H. Pelphry. *Aircraft Prod.*, Nov., 1955, pp. 466–470.

Electrolytic Polishing Technique for Metallographic Specimens in Routine Quality Control; Use of Fast Rotating Cathode. P. M. H. Chawner. *Metal Treatment*, Oct., 1955, pp. 427–429, 432.

Electro-Machining Methods for Metals. A. L. Livshits and V. Ya. Rassokhin. (*Stanki i Instr.*, Moscow, Nov., 1954, Jan., 1955, pp. 12–17, 8–12.) *Engr. Dig.*, Sept., 1955, pp. 429–432. Relative merits of metal-removal or surface-layer modification procedures; applications.

Heavy-Duty Routing. I—Use of High-Speed Milling Heads for Machining Large Airframe Members. L. G. Burnard. *Aircraft Prod.*, Nov., 1955, pp. 428–431.

Rolls-Royce Dart. III—Machining the Rotating Guide-Vanes, Burner-Nozzle Parts and Casing Guide-Vanes. *Aircraft Prod.*, Nov., 1955, pp. 442–450.

Tooling

Automatic Control of Machine Tools at Thompson Products Jet Division. M. M. McMillen and C. O. Parratt. *ISA J.*, Sept., 1955, pp. 346, 347.

Welding

Double-Fillet Test for Research into Hot Cracking of Weld Metal. Appendix—Trials Under Workshop Conditions. K. Winterton and E. G. P. Hinds. *Brit. Welding J.*, Nov., 1955, pp. 513–525.

Fusion Welding of 24S-T3 Aluminum Alloy. J. B. Arthur. *Welding J. Res. Suppl.*, Nov., 1955, pp. 558-s–569-s.

MEN AND MACHINES TEAM UP TO SOLVE PROBLEMS

Teams of men and machines are working at Lockheed to solve tomorrows' problems today. The long range programs of design, development and production require qualified career Engineers in all categories.

New opportunities are constantly opening up and advancements are stepping up in our rapidly expanding Engineering Organization.

R.S.V.P.

JIM WADE
ENGINEERING PROFESSIONAL PLACEMENT

LOCKHEED

AIRCRAFT CORPORATION DEPT. AER-2
761 PEACHTREE N. E., ATLANTA, GEORGIA

Investigation of Weld-Metal Cracking in High-Strength Steel. R. P. Sopher, A. J. Jacobs, and P. J. Rieppel. *Welding J. Res. Suppl.*, Nov., 1955, pp. 544-s–552-s.

Lithium Additions to Brazing Alloys. N. Bredzs and D. Canonico. *Welding J. Res. Suppl.*, Nov., 1955, pp. 535-s–543-s.

A Rational Approach to Welding Titanium; A Note on Argon-Arc Butt Welding of Commercially Pure Titanium Sheet Without Filler Rod. K. L. C. Legg. *Aircraft Eng.*, Nov., 1955, pp. 374, 375.

Seam Welding Dissimilar Thicknesses of Low-Carbon Steel. M. L. Begeman and E. J. Funk. *Welding J. Res. Suppl.*, Nov., 1955, pp. 529-s–534-s.

Propellers

Aerodynamic Characteristics of a Small-Scale Shrouded Propeller at Angles of Attack from 0° to 90°. Lysle P. Parlett. *U.S., NACA TN 3547*, Nov., 1955. 12 pp.

Reference Works

List of Current Papers Published by the Aeronautical Research Council (Numbers 151-200). *Gt. Brit., ARC CP 200.* 1955. 4 pp. 50 refs. BIS, New York. $0.30.

Metal Fatigue: A Bibliography of Unpublished Reports. *Gt. Brit., MOS TIB/BIB(U)/4*, Aug., 1955. 23 pp. 305 refs.

A Survey of Unclassified Axial-Flow-Compressor Literature. I—Flow and Design Theories. II—Experimental Performance and Characteristics. III—End Losses and Secondary Flows. IV—General Historical Interest. Howard Z. Herzig and Arthur G. Hansen. *U.S., NACA RM E55H11*, Nov. 8, 1955. 88 pp. 253 refs.

Refueling in Flight

Probe and Drogue System in Aerial Refueling. Charles A. Speas. *Aero Dig.*, Nov., 1955, pp. 27–32, 37. Flight refueling equipment and requirements of integration into basic aircraft design.

Rotating Wing Aircraft

The Helicopter and Canadian Development. Okanagan Helicopters Ltd. *Can. Aero. J.*, Nov., 1955, pp. 178–182. Survey of operational utilization and potentialities.

Instrumentation Requirements for All-Weather Helicopter Flight. R. F. Bohling. *IRE Trans., ANE Ser.*, Sept., 1955, pp. 10–14. Study of the relative merits of the attitude, heading, altitude, and speed-control equipment to develop criteria to ease complexity problems and to obtain pilot relief through improved display orientation, navigation, and communication.

The Price of Helicopter Transmission Service Life. Richard M. Carlson and F. David Schnebly. *Hiller Helicopters, Paper*, May, 1954. 11 pp.

Design, Development, Production and Servicing of Rotor Blades. R. Allen Price and Frank L. Stulen. *J. Helicopter Assn. Gt. Brit.*, Oct., 1955, pp. 281–294; Discussion, pp. 294–301. Analysis of problems in terms of weight and loading, horizontal thrust, balance control-regulation, structural, aerodynamic, maintenance, fabricational, installation, and other requirements.

Determination of Inflow Distributions from Experimental Aerodynamic Loading and Blade-Motion Data on a Model Helicopter Rotor in Hovering and Forward Flight. Gaetano Falabella, Jr., and John R. Meyer, Jr. *U.S., NACA TN 3492*, Nov., 1955. 184 pp. 10 refs.

The Stiff-Hinged Helicopter Rotor, a New Form of Rotor Giving Improved Performance and Stability. P. R. Payne. *Aircraft Eng.*, Nov., 1955, pp. 358–370. 15 refs.

Reflections on the Interrelation of Helicopter and Heliport Design. J. S. Shapiro. (*Rotterdam Helicopter Cong., July 27–29, 1955, Paper.*) *Aircraft Eng.*, Nov., 1955, pp. 378–383.

Transport Helicopter Design as Related to Operating Cost and Heliport Requirements. F. David Schnebly. *ASCE Air Transp. Div. Meeting, San Francisco, Dec. 15, 1954, Paper.* 24 pp.

Variation on a Rotary Theme. *The Aeroplane*, Nov. 11, 1955, pp. 740–744, cutaway drawing. Design, structural, and performance characteristics of the Westland Widgeon.

Safety

Aircraft Fire Fighting, Extinguishment and Crash Rescue. W. R. Smith. *NFPA Av. Bul. 124*, Apr., 1955. 12 pp.

Crash-Fire Research with Jet Aircraft. I. Irving Pinkel. (*CAI-IAS Internatl. Meeting, Ottawa, Nov. 3, 4, 1955, Preprint 570.*) *Aero. Eng. Rev.*, Jan., 1956, pp. 53–57. Review of NACA investigations of take-off and landing accidents using fully instrumented aircraft accelerated from rest.

Fire Protection and Prevention Equipment in Aircraft. Vernon Brown. *J. SLAE*, Oct., 1955, pp. 3–11.

Full-Scale Performance Study of a Prototype Crash-Fire Protection System for Reciprocating-Engine-Powered Airplanes. Dugald O. Black and Jacob C. Moser. *U.S., NACA RM E55B11*, Nov. 15, 1955. 36 pp.

New Navy Aircraft Crash Fire and Rescue Equipment. Carl Dreesen. *NFPA Av. Bul. 125*, Apr., 1955. 5 pp.

Proposed NFPA 1955 Standard on Fueling Aircraft on the Ground (NFPA No. 407-TR). Appendix A—Preventive Maintenance and Inspection of Aircraft Refueling Hose. Appendix B—Standard for Aircraft Fuel Servicing Vehicles. *NFPA Av. Bul. 119-C*, Mar., 1955. 27 pp.

Time Factors in Passenger Utilization of Emergency Oxygen. Ernest B. McFadden. *U.S., CAA Off. Av. Safety Rep.* May 19, 1955. 7 pp.

Space Travel

International Cooperation in Rocketry and Astronautics. Andrew G. Haley. *Jet Propulsion*, Nov., 1955, pp. 627–632.

Powered Satellite Vehicles. Krafft A. Ehricke. *6th Internatl. Astronautical Cong., Copenhagen, Aug. 1–6, 1955, Paper.* 32 pp. 21 refs.

Prelude to Manned Space Flight. Erik Bergaust. *Pegasus*, Nov., 1955, pp. 1–6. Survey of problems, developments, and potentialities, with a graphical analysis of speed and altitude research trends for different types of aircraft and missiles.

Principles and Performance of Rocket Propelled Vehicles. Adolph K. Thiel. *IAS Meeting, Atlanta, Ga., Jan. 6, 1955, Paper.* 38 pp.

Space Medicine. Herbert Segal. *J. So. African Interplanetary Soc.*, Apr.-Sept., 1954, pp. 24–29. Medical problems under weightless conditions outside the earth's gravitational field in terms of selection of the crew, take off, flight, landing, and life on the objective.

Twenty-Five Years of Progress Toward Space Flight. Milton W. Rosen. *Jet Propulsion*, Nov., 1955, pp. 623–626. 12 refs. Developmental appraisal of problems and trends.

Structures

Notes on a General Method of Treatment of Structural Discontinuities. W. J. Goodey. *J. RAeS*, Oct., 1955, pp. 695–697. Calculations for modified structures, taking into account natural modes and frequencies of vibration.

Unique Structural Problems in Supersonic Aircraft Design. F. P. Mitchell. (*CAI-IAS Internatl. Meeting, Ottawa, Nov. 3, 4, 1955, Preprint 568.*) *Aero. Eng. Rev.*, Jan., 1956, pp. 34–39. Analysis includes factors of loading and weight, fatigue, internal pressure, temperature, creep, and strength.

Uses of the Mohr Circle Pole. T. F. W. Smith. *The Engr.*, Nov. 11, 1955, pp. 696, 697. Direct graphical analysis of stress, strain, and second moments of area.

Beams & Columns

Analysis of the Plastic Collapse of a Cruciform Column with Initial Twist, Loaded in Compression. J. F. Besseling. *J. Aero. Sci.*, Jan., 1956, pp. 49–53. Extension of the Onat-Drucker incremental or flow-type theory of plasticity indicating the large influence of very small thus unavoidable imperfections on the ultimate compressive load.

Average Warping in the Torsion of Thin-Walled Open-Section Beams. A. H. Chilver. *J. Mech. & Phys. Solids*, July, 1955, pp. 267–274.

The Flexure of a Non-Uniform Beam. E. E. Jones. *Pacific J. Math.*, Suppl. I, 1955, pp. 799–806. 13 refs.

On the Behaviour of Infinitely Long Rigid-Plastic Beams Under Transverse Concentrated Load. H. G. Hopkins. *J. Mech. & Phys. Solids*, Oct., 1955, pp. 38–52.

A Theory of the Plastic Yielding Due to Bending of Cantilevers and Fixed-Ended Beams. I, II. A. P. Green. *J. Mech. & Phys. Solids*, Oct., 1954, Jan., 1955, pp. 1–15, 143–155. 21 refs.

Connections

The Influence of Low Temperature on "Redux" Bonded Lap Joints. A. Hartman. *Aero Res. TN Bul. 153*, Sept., 1955. 10 pp.

STRESS ANALYST ENGINEERS

If you are interested in research work that involves strength and fatigue characteristics of new materials . . . if you are qualified to analyze and determine static and dynamic loads . . . you would find that new developments in the field of rotary-winged aircraft are a constant source of inspiration.

Three years of aircraft stress experience or an aeronautical engineering degree are the requisites for the desirable positions now available with the world's pioneer helicopter firm.

Ingenuity and initiative are both welcome attributes and, in conformance with the progressive policy of the company, result in individual recognition and reward. Family well-being, too, is importantly considered, and various insurance plans are provided to afford health protection and retirement income.

Please send a complete resume to Mr. A. E. Auten, Personnel Department.

SIKORSKY AIRCRAFT

ONE OF THE DIVISIONS OF UNITED AIRCRAFT CORPORATION • Bridgeport 1, Connecticut

---

CALTECH

SOUTHERN CALIFORNIA COOPERATIVE WIND TUNNEL

Pasadena, California

AERODYNAMIC DEVELOPMENT AND TEST PROJECT ENGINEERS

B.S., M.S. or Professional Degree in Aeronautics. Theoretical and experimental investigations in the field of wind tunnel design, development and operation.

MECHANICAL DESIGN ENGINEERS

B.S. in M.E. Experience in general mechanical and machine design.

ELECTRICAL DESIGN ENGINEER

B.S. required. Experience in instrumentation or electronic industrial control.

- *Competitive salaries*
- *Outstanding benefits*
- *Opportunity for grad. study*
- *Relocation expenses paid*

Send resume or write for further information to:

Mr. J. N. Ewart

CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena, California

ENGINEERS

THE APPLIED PHYSICS LABORATORY OF THE JOHNS HOPKINS UNIVERSITY offers an exceptional opportunity for professional advancement in a well-established Laboratory with a reputation for the encouragement of individual responsibility and self-direction.

Our program of

GUIDED MISSILE RESEARCH and DEVELOPMENT

provides such an opportunity for men in:

SUPERSONIC MISSILE DESIGN
WIND TUNNEL TESTS AND DATA ANALYSIS
RAMJET DESIGN AND ANALYSIS
MISSILE SYSTEMS DEVELOPMENT
DESIGN AND LAYOUTS OF MISSILE COMPONENTS
RESEARCH AND ANALYSIS IN AERODYNAMIC STABILITY & CONTROL

Please send your resume to: Professional Staff Appointments

APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY

8605 Georgia Avenue
Silver Spring, Maryland

Engineering Instructors NEEDED IN CALIFORNIA

The current expansion program of Northrop Aeronautical Institute is creating several permanent openings for industry-experienced men, with or without teaching experience, to instruct in the various phases of practical Aeronautical Engineering.

FULL OR PART TIME

Retired or semi-retired persons who desire to reside in Southern California can be employed for as little as two or three hours per day.

AMERICAN CITIZENSHIP NOT REQUIRED

If interested write today for full particulars. Please send brief resume of experience and background. Address:

James L. McKinley, Director

NORTHROP AERONAUTICAL INSTITUTE

1197 W. Arbor Vitae Street
Inglewood 1, California

research engineering

FAIRCHILD ENGINE DIVISION IS NOW FORMING THE NUCLEUS OF A NEW GROUP TO WORK ON RESEARCH AND VERY ADVANCED DEVELOPMENT PROGRAMS IN THE FIELD OF PROPULSION

Fairchild Engine Division is currently engaged in development and production of a line of small size turbojet engines and unconventional powerplants. A new Gas Turbine Laboratory and electronic computers afford excellent research facilities.

The Research Group will do research work and consult with the present engineering staff.

SPECIAL OPPORTUNITIES ARE AVAILABLE IN THE FIELDS OF:

SUPERSONIC AERODYNAMICS
COMBUSTION
APPLIED MATHEMATICS AND PHYSICS
HIGH-SPEED ROTATING MACHINERY

Please contact Felix Gardner

FAIRCHILD

ENGINE DIVISION • DEER PARK, L. I., N. Y.

A DIVISION OF FAIRCHILD ENGINE AND AIRPLANE CORPORATION

Where the future is measured in light-years!

Investigation of the Use of a Rubber Analog in the Study of Stress Distribution in Riveted and Cemented Joints. Appendix A—Method of Computing Normal and Shear Stresses. Appendix B—Cemented-Joint Analysis. Appendix C—A Consideration of Problems Introduced by Bending at Ends of Single Lap Joints. Appendix D—Method of Correcting Parallax on X-Ray Negative. Louis R. Demarkles. *U.S., NACA TN 3413*, Nov., 1955. 97 pp. 21 refs.

A Method of Measurement of Elastic and Plastic Deformations and Stresses in Welded Joints (Méthode de Mesures des Déformations Élastiques et Plastiques et des Tensions de Soudure). R. Gunnert. (*Arcos*, Brussels, No. 121, 1951, pp. 3,027–3,043). *Gt. Brit., RAE Lib. Transl. 544*, Aug., 1955. 18 pp. Basic principles, development, and relative merits of the method, comparison to other methods, and a description of a high-precision extensometer and other test apparatus; applications and potentialities.

Stress-Corrosion Cracking of Welded Joints. R. N. Parkins. *Brit. Welding J.*, Nov., 1955, pp. 495–501. 26 refs. Methods of preventing and relieving residual stresses and cracking.

Cylinders & Shells

Impact Pressure Loading of Rigid-Plastic Cylindrical Shells. P. G. Hodge, Jr. *J. Mech. & Phys. Solids*, Apr., 1955, pp. 176–188.

The Influence of Free Ends on the Load-Carrying Capacities of Cylindrical Shells. G. Eason and R. T. Shield. *J. Mech. & Phys. Solids*, Oct., 1955, pp. 17–27.

Photoelastic Determination of Bending Moments in Curved Frames. V. Cadambe and R. K. Kaul. *J. Sci. & Ind. Res., Sect. B*, Oct., 1955, pp. 485–488.

Plastic Twisting of a Circular Ring Sector. A. J. Wang and W. Prager. *J. Mech. & Phys. Solids*, Apr., 1955, pp. 169–175.

Elasticity & Plasticity

The Plastic Bending and Twisting of Square Section Members. M. C. Steele. *J. Mech. & Phys. Solids*, Jan., 1955, pp. 156–166.

Plates

The Bending by Single Loads of Plates with Rectangular Areas of Application (Über die Biegung von Platten durch Einzellasten mit Rechteckiger Aufstandsfläche). S. Woinowsky-Krieger. (*Ingen.-Arch.*, No. 5/6, 1953, pp. 331–338.) *Gt. Brit., MOS TIB/T4497*, Sept., 1955. 12 pp. Translation.

The Buckling Under Longitudinal Compression of a Simply Supported Panel That Changes in Thickness Across the Width. E. C. Capey. *Gt. Brit., RAE TN Struc. 174*, Aug., 1955. 26 pp.

The Effective Width in the Plastic Range of Flat Plates Under Compression. III. Appendix—The Maximum Load of Flat Plates Under Compression. M. Botman. *Netherlands, NLL Rep. S.465*, June, 1955. 68 pp. Results of tests on 18 aluminum 75 S-T and 2S-$^1/_2$H alloy plates.

Formulas for the Elastic Constants of Plates with Integral Waffle-Like Stiffening. Norris F. Dow, Charles Libove, and

Ralph E. Hubka. (*U.S., NACA RM L53E13a*, 1953.) *U.S., NACA Rep. 1195*, 1954. 24 pp.

Instability of Integral Panels. S. Kelsey. *J. RAeS*, Oct., 1955, pp. 699–701. Analysis of the Yusuff results on primary instability for unflanged stiffeners.

Load-Carrying Capacities for Circular Plates of Perfectly-Plastic Material with Arbitrary Yield Condition. H. G. Hopkins and A. H. Wang. *J. Mech. & Phys. Solids*, Jan., 1955, pp. 117–129.

The Local Instability of a Simple Integral Panel. A. H. Chilver. *J. RAeS*, Oct., 1955, pp. 690–693. Theoretical investigation for the case of the panel subjected to uniform end compression in terms of the problems of interconnected flat plates and of the torsional stability of the stiffeners.

A Note on the Minimum Weight Design of a Thin-Walled Stiffened Rectangular Cell Subjected to Torsion. S. Krishnan and V. Cadambe. *J. Aero. Soc. India*, Aug., 1955, pp. 43–47.

On the Plastic Deformation of Built-in Circular Plates Under Impulsive Load. A. J. Wang and H. G. Hopkins. *J. Mech. & Phys. Solids*, Oct., 1954, pp. 22–37.

On the Stresses in Laterally Loaded Plates. Toshiro Suhara. *Kyushu U., Japan, Rep. Res. Inst. Appl. Mech.*, Mar., 1955, pp. 180–183.

Shear Tests on 24 S-T Unstiffened and Stiffened Webs with Flanged Holes. II. M. Botman. *Netherlands, NLL Rep. S.-446*, Nov. 1, 1954. 90 pp., folded charts.

Testing

Airframe Fatigue. L. P. Coombes. *J. RAeS*, Oct., 1955, pp. 701, 702. Appraisal of ARL (Australia) and other investigations on aircraft life expectancy, with reference to the Comet pressure-cabin failures, gust loading, and other operational problems.

Generalized Crippling Analysis of Formed Sections. George Gerard. *J. Aero. Sci.*, Jan., 1956, pp. 88–90. NACA-sponsored development at NYU of an empirical test method as a generalization of the Schuette, Gallaher, and Needham research on formed Z and channel sections.

Mesures Comparatives des Contraintes dans un Modèle Photoélastique Plan, par la Méthode Classique et par la Méthode du Figeage. J. Aubaud. *La Recherche Aéronautique*, May-June, 1955, pp. 41–44. In French. Comparative evaluative measurements on a plan model using the classical photoelastometric and fixed stress methods.

A Note on Methods for the Determination of Transient Stresses. J. W. Mar, T. H. H. Pian, and J. M. Calligeros. *J. Aero. Sci.*, Jan., 1956, pp. 94, 95. Comparative evaluation of force-summation, mode-displacement, and mode-acceleration methods as applied to the analysis of an idealized wing consisting of a uniform beam with a center mass representing the fuselage.

A Safety Device for Double Lever Type Creep Testing Machines. T. Thorley. *Gt. Brit., NGTE Memo. M.194*, Sept., 1955. 8 pp.

Some Work on Tension Pads for Structural Tests. Appendix I—The Method of Bonding Sorbo Rubber Tension Pads to the Loading Plates. Appendix II—Results of Detail Tests. J. K. Oaks and P. B. Hovell. *Gt. Brit., RAE TN Struc. 172*, Aug., 1955. 15 pp.

Thermal Stress

The Determination of Temperature, Stresses, and Deflections in Two-Dimensional Thermoelastic Problems. Bruno A. Boley. *J. Aero. Sci.*, Jan., 1956, pp. 67–75. 14 refs. Development of an analytical successive-approximation method to solve linear partial differential equations applied to bars and plates and to establish a theoretical basis for a thermoelastic strength of materials.

High Temperature Effects in Aircraft Structures. N. J. Hoff. *Appl. Mech. Rev.*, Nov., 1955, pp. 453–455. 62 refs. Analytical review of the literature covering such factors as the reduction of strength and stiffness at moderate temperatures, creep and thermal stresses and buckling, and the effects of creep on stress distribution and failure.

Some Fundamental Experiments on High Temperature Creep. J. E. Dorn. *J. Mech. & Phys. Solids*, Jan., 1955, pp. 85–116. 48 refs. Critical analysis of the varied results of different investigations.

A Study of the Stress-Analysis and Structural-Testing Procedures Applicable to Aircraft Structures at Elevated Temperatures. H. F. Allen, M. A. Brull, and W. J. Wilkie. *USAF WADC TR 54-499*, Oct., 1954. 119 pp. 42 refs. Includes applications of the theory of time-dependent elasticity and the design of a thermal-stress simulator oven container and loading system.

Weight Analysis & Control

Weight Prediction for Wings of Box Construction. Appendix I—Weight of Bending Material. Appendix II—Derivation of Permissible Compressive Stress (f_c). Appendix III—Weight of Torsional Cover. Appendix IV—Weight of Material Carrying Direct Shear Loads in a Vertical Plane. Appendix V—Example of the Method. M. E. Burt. *Gt. Brit., RAE Rep. Struc. 186*, Aug., 1955. 65 pp., folded charts. 16 refs.

Wings

Prestressed Concrete Structures; French System of Wing Construction for Application to Guided Missiles. G. Bruner. *Aircraft Prod.*, Nov., 1955, pp. 456–460.

Thermodynamics

Average Bond Energies Between Boron and Elements of the Fourth, Fifth, Sixth, and Seventh Groups of the Periodic Table. Aubrey P. Altshuller. *U.S., NACA RM E55I27a*, Nov. 18, 1955. 7 pp. 18 refs. A thermochemical analysis.

Combustion

Étude Spectrographique de l'Onde de Déflagration en Régime Laminaire. S. Barrère. *La Recherche Aéronautique*, July-Aug., 1955, pp. 15–24. 14 refs. In French. Spectrographic experiments on laminar flame-front combustion waves for premixed flames of propane, butane, methane, and acetylene combustibles.

Installation d'Essai de Fatigue à Chaud en Traction Ondulée dans les Gaz de Combustion de Pétrole. G. Vidal. *La Recherche Aéronautique*, July-Aug., 1955, pp. 25–29. In French. Technique and apparatus for heat-resistant and traction-wave tests on combustion gases of gasoline under controlled atmospheric conditions to study the behavior of an alloy under the combined and simultaneous effects of temperature, alternating stress, and corrosion.

Studies of Chlorine Trifluoride Flames. G. Skirrow and H. G. Wolfgard. *Proc. Royal Soc. (London), Ser. A*, Oct. 11, 1955, pp. 78–87. Fundamental combustion experiments on idealized diffusion flame processes at the RAE Rocket Propulsion Dept.

Heat Transfer

Convection de Jets d'Air Frappant Normalement une Surface. J. Genot. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 43–46. In French. Study of the convection of air jets directed normally towards a surface of a heat exchanger.

Transient Heat Conduction in Multiphase Media. J. H. Weiner. *Brit. J. Appl. Phys.*, Oct., 1955, pp. 361–363. Analytical solution by an extended Neumann semi-inverse procedure of the problem of a semi-infinite mass of material initially at a uniform temperature, with the surface maintained at a different constant temperature, where the material may change phase an arbitrary number of times in passing from the initial to the final temperature.

Vertical Take-Off Aircraft

Coleopter Combines Wing and Powerplant. A. R. Weyl. *Av. Age*, Nov., 1955, pp. 32 (2 ft.) VTO design features and supersonic performance potentialities of take-off, landing, and maneuverability.

Designing and Testing the Hiller Platform. Arthur C. Robertson. *Aero Dig.*, Nov., 1955, pp. 22–26. Development of the VTO design; problems and potentialities.

Water-Borne Aircraft

Full Scale Measurements of Impact Loads on a Large Flying Boat (Sunderland Mk. 5). II—Results for Impact on Main Step. Appendix I—Outline of the Monaghan-Crewe Theory for Seaplane Water Impacts. Appendix II—Wagner's Formulae for Distributed and Maximum Pressures on Hulls Having Transverse Curvature. Appendix III—Estimation of the Effect of a Vee-Shaped Step on Total Impact Forces and Build-up Time. Appendix IV—Theoretical Relationship Between Two-Dimensional Mean Pressure (P_{mean}) and Maximum Pressure (P_{max}). J. A. Hamilton. *Gt. Brit., ARC CP 205* (Feb., 1951), 1955. 53 pp. 11 refs. BIS, New York. $1.25.

Wind Tunnels & Research Facilities

Aeronautical Research in Sweden. Bo K. O. Lundberg. *J. RAeS*, Oct., 1955, pp. 647–677; Discussion, pp. 677–681. 67

UNDER WAY

... the development of NUCLEAR AIRCRAFT at CONVAIR--Fort Worth

Progress is being made in the Applied Nuclear Field at CONVAIR — Fort Worth — in nuclear analysis, design and experimentation, including the fields of shielding, radiation effects and nuclear aircraft technology.

As an integral part of General Dynamics Corporation's program of pioneering in Nuclear Fields, CONVAIR'S activities afford inviting opportunities for engineers and physicists to enter into Nuclear Development at its most advantageous stage.

CONVAIR'S Nuclear Program offers highly rewarding career opportunities both by way of professional accomplishment and personal income. A company-sponsored, in-plant program enables candidates to earn graduate degrees in Nuclear Engineering.

Fort Worth in the Great Southwest has an abundance of sunshine and dry, fresh air conducive to outdoor living and recreation. Within a few minutes drive of Fort Worth are seven large lakes which provide ample facilities for fishing and other water sports.

For further details write H. A. BODLEY
CONVAIR Engineering Personnel Dept. VV
Fort Worth, Texas

CONVAIR
FORT WORTH

C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
FORT WORTH, TEXAS

refs. Review of FFA investigations in the basic and applied fields of aerodynamics and structures and related areas of measuring techniques.

New Tools for Sweden's Air Research; the Transonic and Supersonic Facilities at the Aeronautical Research Institute of Sweden. B. Reistad. *Saab Sonics*, No. 23, 1955, pp. 18–21.

Experiments on a Slotted-Wall Working Section in a Wind Tunnel. F. Vandrey and K. Wieghardt. *Gt. Brit., ARC CP 206* (Mar. 18, 1952), 1955. 17 pp. BIS New York. $0.50. Development for a water tunnel with correction properties of a free jet for the testing of long streamlined bodies of revolution.

On the Theory of Shock Reflection on Walls with Slots. W. Eckhaus. *Netherlands, NLL Rep. F.167*, July 25, 1955. 20 pp. Derivation of conditions to ensure complete cancellation of reflected disturbances at an infinitely large distance from a wind-tunnel wall.

Control of Surge in Centrifugal Compressors. T. F. McGrath and G. J. Fiedler. *ISA J.*, July, 1955, pp. 234–240. Solution based on frequency response and analog findings and using systems-analysis principles applied to the air-supply design problem of supersonic wind tunnels.

Le Décollement Laminaire en Trois Dimensions. E.-A. Eichelbrenner and A. Oudart. *La Recherche Aéronautique*, Sept.-Oct., 1955, pp. 11–14. Experimental investigation in the Chatillon hydrodynamic wind tunnel of three-dimensional laminar separation governed by the condition $(dv/dn)_p = 0$ applied to the cases of an infinite side-slipping cylinder and an ellipsoid body of revolution inclined with regard to the wind.

Development of a Variable Mach Number Sliding Block Nozzle and Evaluation in the Mach 1.3 to 4.0 Range. Appendix A—Design Details of Flexible Plates and Jacks. Appendix B—Nozzle Seals. Appendix C—Moving Probe Technique. Appendix D—Analysis of Two-Dimensional Test Section Flow by Linear Theory. Appendix E—Contour Tolerances. Appendix F—Diffuser Performance. J. L. Amick, H. P. Liepman, and T. H. Reynolds. *USAF WADC TR 55-88*, Mar., 1955. 56 pp. 10 refs. Asymmetric contour nozzle design for supersonic wind tunnels.

GDF Compressor Selection and Arrangement. C. F. Condrington. *Allis-Chalmers Elec. Rev.*, 2nd Quarter, 1955, pp. 11–13. Design and operation of AEDC Gas Dynamics Facility equipment.

GDF Drive Selection. M. F. Gay. *Allis-Chalmers Elec. Rev.*, 2nd Quarter, 1955, pp. 14–19. Design, operation, and maintenance of the AEDC drive and auxiliary units.

GDF Power Distribution and Control. John Baude and Heinz Buss. *Allis-Chalmers Elec. Rev.*, 2nd Quarter, 1955, pp. 20–24. AEDC installation featuring new protective relaying, metering, and automatic starting procedures.

GDF Wind Tunnel for the World's Highest Air Speeds. C. F. Codrington and M. F. Gay. *Allis-Chalmers Elec. Rev.*, 2nd Quarter, 1955, pp. 8–10. Description of the AEDC Gas Dynamics Facility.

AERODYNAMICISTS

Spectacular Continued Expansion by

MARTIN

Developers and Manufacturers of the Matador, Seamaster, Viking and now the Earth Satellite provides additional openings in

- AERODYNAMIC ANALYSIS
- NEW DESIGN
- WIND TUNNEL TEST

Contact
PROFESSIONAL
EMPLOYMENT

MARTIN

BALTIMORE 3, MARYLAND

DIGITAL COMPUTING

Cornell Aeronautical Laboratory urgently needs two mathematicians experienced in programming and coding problems for stored-program digital computers. A most attractive feature of these two positions is the challenging variety of problems involved. Assignments will cover such fields as dynamics, aerodynamics, vibrations and structures, systems research, missiles systems and statistical analysis.

DUTIES: Consult with Laboratory engineers and scientists and aid them in the statement of their problems. Analyze the problems; set up for digital solution; analyze errors involved, prepare checks for the solution. In general, be responsible for the complete and correct solution to each problem.

SALARY: Up to $9500 depending upon background. Send resume of education and experience to Employment Manager.

CORNELL AERONAUTICAL LABORATORY, INC.

4455 Genesee Street, Buffalo 21, New York

True engineering creativeness brings you up to $15,000 in this position

Airborne Fire Control Engineer —must be a pulse-circuit specialist with range tracker, synchronizer, indicator or circuitry application experience.

Take a vital part with an electronics pioneer in a project that has already attracted top engineering minds.

***To arrange confidential interview, send resume to Box 727, Aeronautical Engineering Review**

NEW PRIME DEVELOPMENT PROJECT at The Garrett Corporation

Newly formed Rex division has immediate openings for Turbomachinery Specialists — unusually interesting, unusually promising.

This is a prime development program which will interest Turbomachinery Engineers who welcome a "ground floor" opportunity with no ceiling on advancement.

This new Garrett division has tremendous growth potential for the engineering staff now being formed.

If you are qualified by experience, are eligible for secret clearance, and are interested in any of the following categories in design, development or drafting, please write for further information to: Robert L. Ehinger, Rex Division, 9851 So. Sepulveda Boulevard, Los Angeles 45, California.

Mechanical Design
Heat Transfer
Stress
Vibrations
Gears
Fuel Systems
Pumps
Combustion
Controls
Aerodynamics
Testing
Instrumentation
Materials
Lubrication
Seals

THE GARRETT CORPORATION
REX DIVISION
Los Angeles 45, California

IAS Preprints

Preprints of 24th Annual Meeting Papers Currently Available

		Member Price	Nonmember Price
637	Effect of Spanwise and Chordwise Mass Distribution on Rotor Blade Cyclic Stresses—H. Hirsch, R. E. Hutton, and A. Rasumoff.	$0.50	$0.85
636	Guided Missile Propulsion—T. Keating.	0.35	0.75
635	Helicopter Blade Vibration and Flutter—R. H. Miller and C. W. Ellis.	0.65	1.00
634	Some Principles of Missile Guidance—Col. R. C. Gibson.	0.35	0.75
633	An Investigation of Effects of Certain Types of Structural Nonlinearities on Wing and Control Surface Flutter—D. S. Woolston, H. L. Runyan, and R. E. Andrews.	0.50	0.85
632	An Experimental Study of the Response of Simple Panels to Intense Acoustic Loading—L. W. Lassiter, R. W. Hess, and H. H. Hubbard.	0.35	0.75
631	Noise, Vibration, and Aircraft Structures—Arthur A. Regier.	0.50	0.85
630	Crash Fire Prevention—Research to Flight Test—E. R. Zeek and I. J. Hammill.	0.35	0.75
629	Stagnation Point of a Blunt Body in Hypersonic Flow—Ting-Yi Li and Richard E. Geiger.	0.50	0.85
628	The Impact of Electronic Equipment on Electric Generator Design and Aircraft Power Plants—Henry Rempt and M. J. Cronin.	0.50	0.85
627	Cooling Procedures Necessary to Avionic Reliability—J. P. Welsh.	0.35	0.75
626	Helicopter Flight Trainer—Luis de Florez and E. K. Smith.	0.50	0.85
625	A Discussion of Helicopter Vibration Studies Including Flight Test and Analysis Methods Used to Determine the Coupled Response of a Tandem Type—John E. Yeates, Jr.	0.35	0.75
624	Reverse Thrust, Vertical Lift, and Side Force by Means of Controlled Jet-Deflection—Leonard Meyerhoff and Stanley A. Meyerhoff.	0.65	1.00
623	Integrated Flight Equipment System with a Primary Emphasis on the Instrumentation and Controls—C. F. Fragola and M. A. Sant Angelo.	0.35	0.75
622	Heat Transfer Characteristics of a Hemisphere Cylinder at Hypersonic Mach Numbers—Eva M. Winkler and J. E. Danberg.	0.50	0.85
621	An Application of the Ducted Propeller of a VTOL Transport Airplane—James A. O'Malley, Jr.	0.35	0.75
620	Analytical Determination of the Natural Coupled Frequencies of Tandem Helicopters—G. Brooks.	0.50	0.85
619	On the Flutter of Swept Wings—Peter F. Jordan.	0.50	0.85
618	Some Design Considerations for Tear-Resistant Airplane Structures—Arne Sorenson.	0.50	0.85
617	Recent Developments in the Theory of Wing-Body Wave Drag—H. Lomax and M. A. Heaslet.	0.65	1.00
616	Aircraft Electronic Equipment Contoured vs. Standard—R. J. Henderson and G. P. Allison.	0.35	0.75
615	Prediction of Downwash at Various Angles of Attack for Arbitrary Tail Locations—J. L. Decker.	0.50	0.85
614	Some Aerodynamic Considerations of Nozzle-Afterbody Combinations—E. M. Cortright, Jr.	0.35	0.75
613	Common System Development, 1956—James L. Anast.	0.35	0.75
612	The Problem of Cooling Electronic Equipment in High Performance Aircraft—N. A. Carhart.	0.50	0.85
611	Experimental Investigation of Leading Edge Shock Wave-Boundary Layer Interaction at Hypersonic Speeds—James M. Kendall, Jr.	0.50	0.85
610	Piston Theory—A New Aerodynamic Tool for the Aeroelastician—H. Ashley and G. Zartarian.	0.65	1.00
609	Project VANGUARD—The IGY Earth Satellite—Rear Admiral F. R. Furth.	0.35	0.75
608	Dynamic Considerations Relating to the Behavior of Inertial Space-Stabilized Platforms—E. Gorczycki.	0.35	0.75
607	A Precision Servo-Type Thermocouple Temperature Indicating System—George H. Cole.	0.35	0.75
606	Safety and Economic Aspects of Flight Simulators—A. F. Bonnalie.	0.50	0.85
605	A Two-Dimensional Approximation to the Unsteady Aerodynamics of Rotary Wings—R. Loewy.	0.65	1.00
604	Transient Stresses in Airfoils Subjected to Blast Loading—F. J. Marshall and H. F. Ludloff.	$0.65	$1.00
603	Optimalizing Cruise Control for Turbojet Aircraft, Part I—W. B Bryant, Y. T. Li, and H. L. Pastan and Programmed Cruise Control for Turbojet Aircraft, Part II—M. A. Hoffman, Y. T. Li, and A. J. Navoy.	0.65	1.00
602	Mass Flowmeter Summation System—Clarence A. Haskell.	0.35	0.75
601	Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds—R. Whitcomb.	0.35	0.75
600	Investigation of Whirl Test Methods for Inducing Flight Fatigue Loads in Helicopter Rotors—C. F. Rice.	0.50	0.85
599	Design and Flight Test Development of McCulloch YS-57 Supercharger Installation on Hiller Model UH-12B Helicopter—R. D. Collins, R. W. Cowgill, and R. H. David.	0.35	0.75
598	Navy Requirements for Air Navigational Aids, Communications Facilities, and Air Traffic Control 1955–1975—H. I. Rothrock.	0.35	0.75
597	Examination of Some of the Problems Involved in the Design of Propeller-Driven Vertical-Take-Off Transport Airplanes—M. O. McKinney, R. E. Kuhn, and J. B. Hammack.	0.50	0.85
596	A Study of the Transition of Turbulence of the Laminar Boundary Layer at Supersonic Speeds—Ronald F. Probstein and C. C. Lin.	0.75	1.20
595	The Effect of Blade Root Properties on the Natural Mode Shapes, Bending Moments, and Shears of a Model Helicopter Rotor Blade—H. Daugheday and F. DuWaldt.	0.50	0.85
594	Induction System Selection—Harry Drell and Thomas A. Sedgwick.	0.50	0.85
593	Experimental and Analytical Investigation of Secondary Flows in Ducts—A. Hansen and H. Herzig.	0.35	0.75
592	Air Traffic Facts—A. D'Arcy Harvey.	0.35	0.75
591	Probe Measurement of Pressure Distribution on Oscillating Wings in Supersonic Flow—Erik Mollo-Christensen, Robert L. Halfman, and S. Dean Lewis.	0.50	0.85
590	Integration of Weather Forecasting, Flight Planning, and Flight Watch—Thomas L. Burkett and Irving I. Gringorten.	0.50	0.85
589	Improved On-Off Missile Stabilization—Robert W. Bass.	0.25	0.50
588	Demonstration of Reliability in Liquid Propellant Rocket Engines—A. G. Thatcher and H. A. Barton.	0.25	0.50
587	Delay of the Stall by Suction Through Distributed Perforations—A. Raspet, J. J. Cornish, III, and G. D. Bryant.	0.50	0.85
586	Structural Behavior of Seaplane Hull Bottom Plating—J. W. Cox.	0.65	1.00
585	Effect of Rib Flexibility on the Vibration Modes of a Delta Wing Aircraft—Wilhelmina D. Kroll.	0.50	0.85
584	The Turbine Propeller Combination in the Air Force—Lt. Colonel Roy J. Wellman.	0.35	0.75
583	All Weather Flight Concern of the Pilot and Weather Forecaster—James K. Thompson.	0.35	0.75
582	Implications of Convective Cloud Observations with Regard to Flight Operations with Airborne Radar—Louis J. Battan.	0.50	0.85
581	Minimal Flight Paths from Forecasts of the Joint Numerical Weather Prediction Unit—Frank Lewis.	0.35	0.75
580	The Display of Hail Echoes on 5.5 CM Weather Mapping Radar—Henry T. Harrison.	0.50	0.85
579	Influence of Aerodynamic Heating on the Effective Torsional Stiffness of Thin Wings—Bernard Budiansky and J. Mayers.	0.65	1.00
578	Approximate Procedures for Transient Thermal Stresses in Missile Structures—B. E. Gatewood.	0.50	0.85
577	Investigation of the Temperature Distribution and Thermal Stresses in a Hypersonic Wing Structure—Martin A. Goldberg.	0.50	0.85
576	Thermal Stresses and Deformations in Beams—Samuel Levy.	0.50	0.85

Order by number from: Preprint Dept., IAS, 2 E. 64th St., New York 21, N.Y.

Aeronautical Reviews — BOOKS

AEROELASTICITY

Aeroelasticity. Raymond L. Bisplinghoff, Holt Ashley, and Robert L. Halfman. Cambridge, Addison-Wesley Publishing Co., Inc., 1955. 860 pp., illus., diagrs., figs. $14.50.

This book is intended both as a textbook for advanced engineering students and as a reference book for practicing engineers. The authors, all Professors of Aeronautical Engineering, Massachusetts Institute of Technology, have selected their material according to their belief that the practical aspects of aeroelasticity should be treated in conjunction with an integrated treatment of the aerodynamic and structural tools upon which applications are based. Each chapter is written with a view to accommodating both the engineer who wants completeness and the instructor who may want to select from the several topics under each chapter heading.

Contents: (1) Introduction to Aeroelasticity. (2) Deformations of Airplane Structures under Static Loads. (3) Deformations of Airplane Structures under Dynamic Loads. (4) Approximate Methods of Computing Natural Mode Shapes and Frequencies. (5) Aerodynamic Tools: Two- and Three-Dimensional Incompressible Flow. (6) Aerodynamic Tools: Compressible Flow. (7) Wings and Bodies in Three-Dimensional Unsteady Flow. (8) Static Aeroelastic Phemonena. (9) Flutter. (10) Dynamic Response Phenomena. (11) Aeroelastic Model Theory. (12) Model Design and Construction. (13) Testing Techniques. Appendices. References. Author Index. Subject Index.

AERONAUTICS, GENERAL

Sound Barrier; The Story of High-Speed Flight. Neville Duke and Edward Lanchbery. 6th Ed. New York, Philosophical Library, Inc., 1955. $4.75.

Now in its second, revised edition, this book brings together in nontechnical language a great deal of information pertaining to the high-speed airplane, the natural elements through which it flies, and the human factors that must be considered in the design of such aircraft. Generously illustrated, it provides clear definitions and summary data for many of the questions that confront the layman who seeks to inform himself about aviation in its present state of development.

CONTROL SYSTEMS

Analysis of Feedback Control Systems. Robert A. Bruns and Robert M. Saunders. New York, McGraw-Hill Book Company, Inc., 1955. $7.50.

This book presents a rigorous treatment of feedback control components and systems. The most recent literature in the field has been surveyed and evaluated in presenting a unified method of analysis consistent with the technical background of those new to the field. This work should enable the reader to analyze systems of considerable complexity and to develop a good background for synthesis techniques. The frequency response approach is used throughout. Emphasis on this approach, for which alternating current circuit analysis is the only prerequisite, makes the transfer-function method of analysis an important feature of the book. Thus, in the 10 chapters devoted to component theory, the basic physical laws governing the behavior of components are interpreted in terms of their transfer functions without the introduction of new mathematical concepts. Components covered are not restricted to any one field, but include electrical, magnetic, mechanical, pneumatic, and hydraulic elements. The authors emphasize the implementation of systems by giving the student the basic theory of components. Recent developments in nonlinear and discontinuous systems, particularly the describing-function method, are included. Illustrative examples are used liberally, especially in the system theory chapters. Robert A. Bruns is a research engineer, Jet Propulsion Laboratory, California Institute of Technology; Robert M. Saunders is Associate Professor of Electrical Engineering, University of California.

Servomechanisms and Regulating System Design, Vol. 2. Harold Chestnut and Robert W. Mayer. New York, John Wiley & Sons, Inc., 1955. 384 pp., diagrs., figs. $8.50.

Volume I, published in 1951, was adapted to the needs of engineers and engineering students who did not have previous training or experience in the field of closed-loop control. This second volume is devoted to the needs of the practicing designer and the advanced graduate student. It presents the necessary additional information with which the requirements of the equipment user may be rephrased into the terms of the control system designer. In addition, the design steps required to convert the control system parameters into suitable hardware terms are stressed so that dependable and serviceable equipment can be obtained. The authors, who are both of the Aeronautics and Ordnance Systems Division, General Electric Company, have brought the text up to date to reflect advances made in nonlinear control systems since issuance of the first volume.

Contents: (1) Measurement Techniques. (2) Influence of Input Characteristics on Control System Design. (3) Selection of Controlled System Power Element with Proper Rating. (4) Networks for Obtaining Desired Attenuation-Frequency Characteristics. (5) Amplifier Design. (6) All Alternating-Current Servomechanism Operation. (7) Linearization of Non-Linear Elements for Small Departures. (8) Linearization of Non-Linear Elements for Large Departures. (9) Application of Non-Linear Elements to Control Systems.

For information on IAS Library Services, see page 101

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

INSTRUMENTS

Electronic Measuring Instruments. E. H. W. Banner. New York, The Macmillan Co., 1955. 395 pp., illus., $8.50.

In this book the author surveys the whole field of electronic measurement for very high and very low values, for remote indication, and for increased accuracy. Part I covers the characteristics of the indicating instruments used in electronic measurement. Part II describes the electronic circuits. Part III gives the application of the circuits to the complete instrument. Part IV covers those instruments which contain some electronic element.

POWER PLANTS

Diesel Engine Principles and Practice. C. C. Pounder, Editor. New York, Philosophical Library, Inc., 1955. 848 pp., illus., figs. $17.50.

This volume is a comprehensive reference book, arranged in 26 sections, covering the theory, construction, and applications of Diesel engines of all types. Each section is a self-contained treatise on one aspect of Diesel engineering, written by a specialist in his particular field. The book begins with a group of chapters on the theory and components of Diesel engines, starting with the thermodynamic principles and continuing with fuels, fuel injection systems, scavenging arrangements, pressure-charging blowers, heat exchangers, starting apparatus, transmission gear, and governors. Sections follow on torsional vibration, engine balancing, materials, and crankcase explosions. The central part of the book describes different types of engines in ascending order of size, beginning with vehicle and tractor engines and proceeding through the various types of marine, railway, and stationary engines. These sections give a comprehensive survey of typical engines for every application, with many useful tables. The book concludes with sections on vibration and noise, testing, and engine maintenance.

ROTATING WING AIRCRAFT

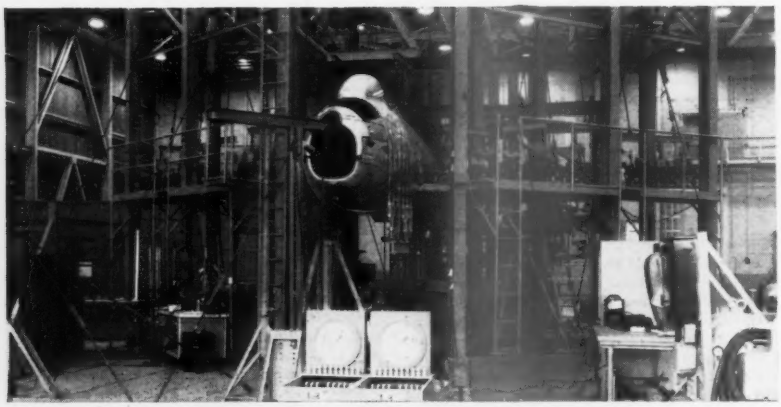
Report of Second Helicopter Meeting, International Air Transport Association, held in Brussels, February 23–25, 1955. Montreal, IATA, 1955. 83 pp., diagrs.

This report contains the IATA recommendations in five areas of helicopter transportation operations which the Helicopter Group established at their second meeting. The topics under discussion were: heliports, multiengined helicopter performance, NAV/COM facilities and equipment, air traffic control, and presentation of technical information required from manufacturers.

The Complete Book of Helicopters. D. N. Ahnstrom. New York, World Publishing Co., 1954. 159 pp., illus., diagrs. $4.95.

Written for the layman, this book by an editor of *Skyways* is intended to give a brief review of the development of the helicopter from its ancestry to its modern form, together with an elementary idea of how it operates.

NORTH AMERICAN'S Columbus Division



...A Complete Airframe DESIGNER and BUILDER in OHIO OFFERS CAREERS to ENGINEERS

With the highly-successful NAVY FJ-4 FURY JET* in production, and with other, years-ahead designs being developed, North American's Columbus Division has become a self-sufficient, proficient organization within North American Aviation, the company that has built more airplanes than any other in the world.

Geographically, a complete airframe manufacturer in Ohio offers individual advantages to many engineers. The Division's complete design, development and manufacturing responsibility for North American's Naval planes is its own Challenge. North American Aviation means Stability plus availability of vast engineering data and resources. The Division's youth and success mean greater Individual Opportunity.

A SELECT FEW POSITIONS ARE OPEN IN EACH OF THESE FIELDS:

Aerodynamicists, Thermodynamicists, Dynamicists, Stress Engineers, Structural Test Engineers, Flight Test Engineers, Mechanical and Structural Designers, Electrical and Electronic Engineers, Wind Tunnel Model Designers and Builders, Power Plant Engineers, Research and Development Engineers, Weights Engineers.

For the Full Story On Your Ohio Future, Write Today: Mr. J. H. Papin, Personnel Manager, Department 56AE, North American's Columbus Division, Columbus 16, Ohio.

Engineering Ahead for a Better Tomorrow

NORTH AMERICAN AVIATION, INC.

*Reg. U.S. Pat. Off. **COLUMBUS DIVISION**

THERMODYNAMICS

Introduction to Statistical Thermodynamics. Malcolm Dole. New York, Prentice-Hall, Inc., 1954. 250 pp., diagrs., figs. $6.25.

This is a textbook for a course designed to bridge the gap between thermodynamics and kinetics on the one hand, and chemistry and physics on the other. In order to clarify and simplify the approach to this difficult field, the author first briefly reviews the fundamentals of classical thermodynamics and presents the principles of statistical mechanics. He then proceeds to show how these two subjects relate to each other in statistical thermodynamics. Specific practical applications of these principles are introduced as quickly as possible, and a balance between theory and practice is maintained throughout the text. The author is Professor of Chemistry at Northwestern University and a consultant to the Oak Ridge National Laboratory.

Contents: (1) Introduction. (2) Brief Introduction to Mathematical Probability. (3) The Distribution of Molecular Weights in Linear Condensation Polymers. (4) Some Fundamental Ideas of Statistical Mechanics and the Equation for the Probability of the Most Probable State. (5) Derivation and Significance of the Boltzmann Distribution Law. (6) The Interionic Attraction Theory of Strong Electrolytes. (7) Relation of Thermodynamic Functions to the Partition Function. (8) Preliminary Considerations in the Evaluation of the Partition Function. (9) Evaluation of the Translational, Rotational and Vibrational Partition Functions for Perfect Gases. (10) The Heat Capacity of Gases and Solids. (11) The Calculation of Equilibrium Constants.

Thermodynamics. Franklin P. Durham. New York, Prentice-Hall, Inc., 1954. 312 pp., diagrs. figs. $7.35.

The author, a member of the faculty of the University of Colorado, has written a textbook for undergraduates which essays to avoid certain difficulties encountered by the student in mastering the basic relations. Developing the basic theory in terms of a minimum number of simple equations in the first six chapters, he summarizes the fundamental relations in the following chapter—Thermodynamic Processes—where they are divided into two groups, those that apply to any medium and those that apply to the ideal gas. Chapters Eight through Twelve discuss specific applications of the theory and are followed by chapters on Gas Dynamics and on Heat Transfer. There are nine tables and five charts plus an index appended to the book.

WIND TUNNELS

Dynamic Measurements in Wind Tunnels. Lee Arnold. (AGARDograph No. 11.) Paris, NATO, AGARD; Washington, NACA, August, 1955. 68 pp., diagrs. 42 refs.

The author, who heads the consulting firm bearing his name, presents the current status of the art of measuring unsteady aerodynamic forces and also that of model-testing from the standpoint of dynamic stability and flutter. Model construction, instrumentation, and scale effects are also discussed. Developments in the various NATO countries are described, and possible alternate procedures are suggested. This is one of a series of AGARDographs on the wind tunnel.

Turbulence Measurements with the Hot-Wire Anemometer. Ralph D. Cooper and Marshall P. Tulin. (AGARDograph No. 12.) Paris, NATO, AGARD; Washington, NACA, August, 1955. 58 pp. 63 refs.

Another in the AGARDograph series on wind tunnels, this treatise concerns the use of hot-wire anemometry techniques in the measuring of turbulence. Considerable attention is given to the subject of turbulence itself and to an analysis of the anemometer, its components and their respective functions. A table which describes in outline 36 important experiments in this field is appended to the text. Mr. Cooper is with the Hydromechanics Laboratory of the David W. Taylor Model Basin. Mr. Tulin is with Office of Naval Research.

Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Stress Analysts and Structures Engineers—Growing engineering research and development organization needs men with 1–5 years' experience preferably in thermal and stress analysis, aircraft or missile structural work. Apply Personnel Department, Aerophysics Development Corporation (subsidiary of Studebaker-Packard), Box 949, Santa Monica, Calif.

Aeronautical Engineers—The National Advisory Committee for Aeronautics is offering varied employment opportunities in many fields of aeronautical research for both recent graduates and experienced engineers. Aeronautical Engineers are required for research in problem areas such as the following: Supersonic aerodynamics, boundary-layer and heat-transfer studies, viscous flow and separation, blading and cascades, mixed flow, compressor surge, turbine cooling, matching of compressors turbines. Application of combustion fundaments to design of combustors to operate beyond current limits; fuel injection and turbulence mixing. Aerodynamic instruments for basic measurements in high-velocity compressible gas streams, hot-wire anemometry; electronic analog computers for theoretical studies. Full-scale engine research to study rotating stall, altitude blowout; turboprop, turbojet, and ram-jet performance at high speeds and extreme altitudes; inlet flow distortion, thrust augmentation, jet-ejectors, thrust reversal, screech suppression; special cycles of turbo-gas-generator with tip-burning pressure jets for rotorcraft; vertical take-off aircraft; power-plant installation; operational limitations and control problems for ram-jet, turbojet, and turboprop engines. Nuclear reactor analysis for aircraft propulsion; heat-transfer rates and media; cycle analysis for nuclear engine. These positions offer challenging assignments, a professional atmosphere among experts, and recognition on a national and even international level. Excellent opportunities for creative research. Salaries are commensurate with qualifications and assignments. Advanced study is encouraged and may be pursued while in full-pay status. Ample leave and other fringe benefits are provided. Further information may be obtained by writing: NACA, Lewis Flight Propulsion Laboratory, Room 350, ASB, 21000 Brookpark Road, Cleveland 11, Ohio.

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Associate Professor or Professor—Staff opening available for appointment beginning March 15 or September 1, 1956. Applicant should be qualified to teach undergraduate and graduate courses in aerodynamics, also to direct and carry out research. Enclose an outline of education, experience, and references in initial reply. Ph.D. degree desirable. Send replies to: Professor E. W. Anderson, Head, Dept. of Aeronautical Engrg., Iowa State College, Ames, Iowa.

Aeronautical Engineer—Individual with B.S. degree in Aeronautical Engineering and 1–3 years in applied aerodynamics. He will be doing calculations on stability and control, classic and power-plant performance. Should be capable of reducing aerodynamic data to equation form suitable for electronic simulation. Good opportunities for advancement. Excellent employee benefits and suitable housing available. Send résumé to: W. W. Wood, Vice-President, Engineering, Link Aviation, Inc., Binghamton, N.Y.

Research Scientists—The Aeronautical Research Laboratory of the Wright Air Development Center has openings for qualified research scientists in fluid dynamics, to work on creative problems associated with high-speed aircraft and missiles. The work carried on in the Laboratory involves both theoretical and experimental approaches; the individual's preference for the type of problem and method selected for its solution is given prime consideration in work assignments. Scientists are needed to work on problems in hypersonic gas dynamics, turbomachinery, propulsion, combustion, research facilities, and heat transfer. Vacancies exist in the GS-11 through GS-14 (starting salary $6,390 through $10,320 per annum) for qualified, experienced people with formal training in physics, aeronautical engineering, or mechanical engineering. Inquiries relative to these positions should be directed to: Chief Aeronautical Research Laboratory (WCRR), Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. State briefly the type of research preferred together with a résumé of qualifications and experience, the latter preferably on a Civil Service Form 57, (which can be obtained at any U.S. Post Office). Inquiries will be given prompt attention.

Engineers—Reaction Motors, Inc., Denville, N.J. (less than 1 hour from New York City), have a number of openings for engineers in the rocket propulsion field. Challenging opportunities are available for men with experience or training in design and stress work in aircraft engines or airframe field; other openings are available for aeronautical, mechanical, and electrical engineers with experience in power-plant installation, thrust chamber and injector design, combustion stability, rocket engine testing and instrumentation, seat catapult ejectors, servocontrols, system analysis, etc. Please send résumé including salary requirements to: Employment Manager, Reaction Motors, Inc., Denville, N.J.

Engineers—Electromechanical—Our firm has been established since before World War II in the manufacture of aircraft equipment. Although small, we have shown consistent growth and are now expanding our activities in the manufacture of gyro mechanisms, accelerometers, potentiometers, and other electromechanical devices. We need competent engineers at various levels, including Chief Electro Engineer, to work on design problems. Please send résumé to: E. L. Hearsey, Sturgess, Inc., 621 South Hope Street, Room 1023, Los Angeles 17, Calif.

Engineering Instructors—Increased enrollment requires teaching staff expansion creating several openings soon for industry-experienced men, with or without teaching experience, to serve as instructors in the various phases of practical aeronautical engineering. Retired or semiretired persons desiring California residence and light work load can be employed for as little as 2 or 3 hours per day. American citizenship not required. Our leaflet of full particulars about our kind of teaching, also the school catalog, will be furnished on request. Send replies to: C. T. Reid, Director of Engineering, Northrop Aeronautical Institute, 1199 W. Arbor Vitae Street, Inglewood 1, Calif.

719. Analytical Engineers, Engineering Physicists, Applied Mathematicians—Expanding re-

ENGINEER, ME or AE

Design Engine Units for Nuclear Powered Flight

The next big advance in aviation is nuclear powered flight, a field which offers exceptional possibilities for professional achievement. This major company, located in the Midwest and West, now has a position open in this new field.

Qualifications include 2 to 6 years' experience in thermodynamics and aerodynamic development. Work involves thermodynamic and fluid flow aspects of turbine type aircraft engines and components.

Address replies to:

Box 728 Aeronautical Engineering Review

When you write to manufacturers whose advertising appears in the

Aeronautical Engineering Review,

it will be of interest to the companies and of benefit to the Institute if you mention that you saw it in the

Aeronautical Engineering Review

Engineers whose minds travel 7 miles per second*

find a rewarding future in rocketry at

REACTION MOTORS

Here are futures not bounded by the narrow limits of specialization or regimented production. At Reaction Motors, YOU are the engineer

The problems provoked by man's determination to conquer time and space, to establish service satellites, to master the force of gravity and to develop precision in rockets will challenge your creative abilities. And the solutions add immeasurably to your professional stature.

Here at RMI you have at your disposal the tremendous research facilities and the accumulated technical skill gathered through 14 pioneering years of rocket research and development. All the important speed and altitude records for planes and single stage rockets are held by aircraft or missiles powered by engines developed by Reaction Motors.

If you ARE an engineer whose mind travels 7 miles per second, you'll reap a richer harvest at RMI. And you'll enjoy working in a completely equipped, brand new four million dollar plant in the heart of New Jersey's lake and mountain resort area, just 50 minutes from New York City.

We Have Immediate Openings For Men With Experience or Training In The Following Fields:

- Stress Analysts—Aircraft Engines or Airframes
- Environmental Testing of Components
- Aircraft Power Plant Installation
- General Project Engineering Work
- Engine Controls and Controls Systems
- Design of Airframe or Aircraft Engine-Type Parts
- Servo-Mechanisms
- Solid Propellant Grain Design for Seat Catapult Ejection Systems
- Thrust Chamber and Injector Design and Combustion Stability
- Design and Development of Hydraulic, Pneumatic and Mechanical Components and System Synthesis
- Analysis and Consultation on Rocket Engines and Power Plant Systems
- Formulation of Control System Problems, Computer Set-Up and Solution Analysis
- Rotating Machinery Design and Consultation
- Rocket Engine Testing and Instrumentation
- Internal Combustion for Jet or Rocket Engine Applications
- Preliminary Design or Proposal Experience in Aircraft Power Plant Field

RMI

REACTION MOTORS, INC.

"First in Rocket Power"

FORD ROAD DENVILLE, N. J.

AFFILIATED WITH THE OLIN MATHIESON CHEMICAL CORP.

Send Complete Resume Including Experience & Salary Requirements to Employment Manager

*Earth's Escape Velocity

search, development, and consulting organization has exceptional openings for senior personnel interested in applying the most advanced scientific knowledge to engineering problems. Experience in one or more of the following fields is desired: aerodynamics, heat transfer, aerothermodynamics, system dynamics, and performance analysis. These are top positions for personnel capable of independent work and supervision of others. Salary $12,000–$14,000. Our activities are in advanced missiles, jet engines, and nuclear power plants. Northern New Jersey location.

717. Applied Hydrodynamicist—With strong background in fundamental fluid dynamics for position of senior project engineer with moderate size research organization. Applicant should be familiar with potential flow theory, etc., and be capable of handling such problems with minimum of supervision. Opportunity for graduate study. At least 3 years of experience. Starting salary $6,000 to $8,500 depending upon qualifications. Location metropolitan New York area. Enclose résumé of education and experience with initial reply.

716. Graduate Engineer or Physicist—Young graduate engineer or physicist for experimental research and development work in aero- and hydrodynamics with moderate size research organization. Supported graduate study program. Opportunity for advancement. Starting salary $4,200 to $5,000 depending upon experience. Location metropolitan New York area. Enclose résumé of education and experience with initial reply.

712. Chief Engineer—Well-established helicopter company with progressive expansion program, East Coast area, requires Chief Engineer with outstanding record of technical achievement—helicopter design; extensive helicopter test pilot background preferred. All inquiries confidential.

Available

718. Technical Executive—Can administer own group or assist top executive in program (or product) planning, design, development, or research. Strong in building and handling personnel. Broad interests supported by integrated background in wide range of light to heavy mechanical items and associated fields. M.E., advanced degree, 20 years' experience.

715. Technical Director—B.S. in Ae.E. 18 years of management, aircraft sales, and component (except electronics) experience. Extensive experience in Air Force weapon system concept and programs. Desires direct sales or representative position in Washington, D.C., area.

714. Aeronautical Engineer—Jet Pilot—B.S. in M.E.-A.E. with 8 years' flying experience and over 1,000 hours in all types of Air Force jet fighters. Commercial license—single engine land. Presently employed by leading aircraft firm as flight-test engineer, while flying jet fighter for the Air National Guard. Desires a flying position in which can utilize engineering knowledge. Location not essential.

713. Test Engineer—Ten years' experience evaluating advanced systems, guided missile and aircraft, laboratory and flight. Includes planning of complete weapons system evaluation program. B.S. and M.S. degrees.

710. Research Pilot-Engineer—Flight testing from World War II on—includes a wide variety of types and projects. Engineering experience as designer, project engineer, and teaching. Basic and advanced degrees. Requires work which calls for application of top drawer flying and engineering capabilities. Available January.

709. Staff Engineer—B.Aero.E. plus graduate mechanical and metallurgical engineering work; 4 years' diversified structural, propulsion and nuclear experience. Past 8 years in sales administration, and subcontractor control in a nonengineering business. Interested in sales, customer, or vendor liaison, administration, development work. Prefers Long Island metropolitan area but will relocate if necessary.